ENGINEERING

An Illustrated Weekly Journal

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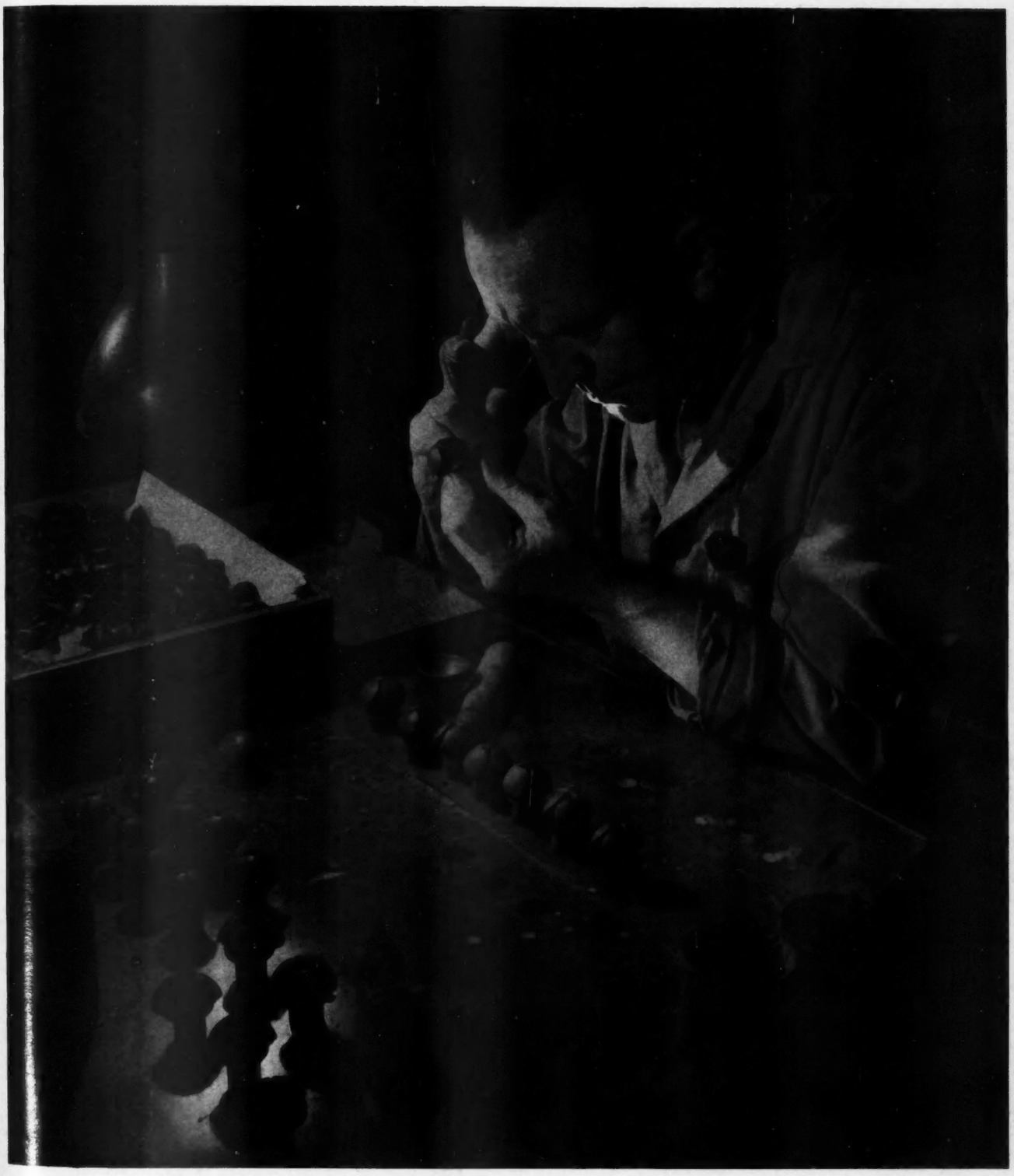

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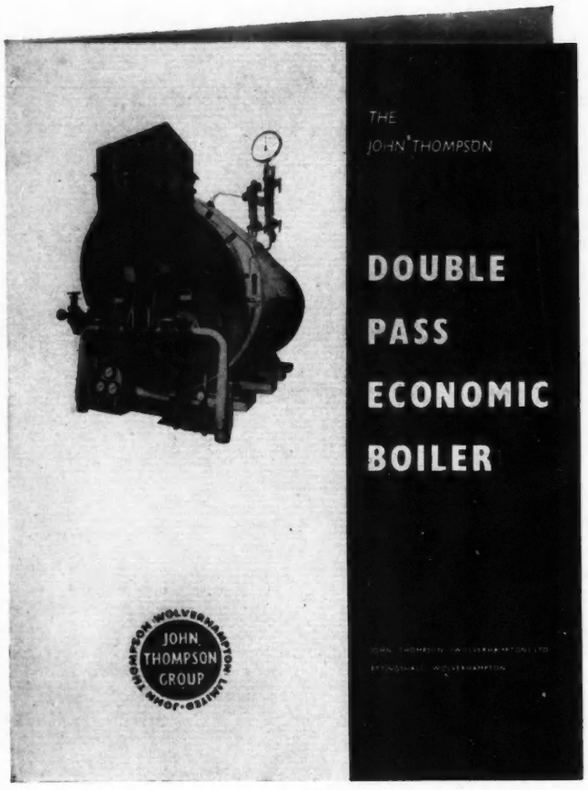
THE DOUBLE PASS ECONOMIC BOILER



This leaflet should be in the reference files of every Company that uses steam. The leaflet describes the John Thompson *Double Pass* Economic Boiler, and its contents include a cut-away illustration showing the general arrangement within the Shell, and a table of sizes and evaporations.

Interested Companies and individual steam engineers are invited to let us have their names and addresses so that we may mail copies of the leaflet to them.

This particular leaflet is devoted to the Double Pass Economic Boiler, but the Company specialises in the design and layout of complete steam installations based on all types of shell boilers. Our technical staff are available at all times to assist in the design and layout of steam installations to meet individual requirements.

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Vol. 179 No. 4644 JANUARY 28, 1955

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PATRON OF THE ARTS

WHEN Lorenzo de' Medici invited the great Renaissance painter, sculptor and architect Michelangelo to his court in Florence, he was performing for humanity a service which has long been the special privilege of rich and powerful men. Without the encouragement and support of wealthy patrons, many talented artists and craftsmen might have remained obscure and their finest works uncommissioned; in consequence, the world would be an immeasurably poorer place. In many countries to-day wealth is much more equably distributed and men of such great riches are somewhat less abundant; thus that duty, once so admirably performed by private individuals, is now extensively fulfilled by corporate concerns.

Where at one time a Medici or a Sforza commissioned a celebrated architect to conceive a palace, industry now requires a factory or an office block, and sets standards equally high. Utility is seldom inconsistent with beauty, and industry, formerly noted for the prosaic drabness of its habitation, has found this to be true. The impressive chemical plant at Sunila, designed by the Finnish architect, Alvar Aalto, and the Boots factory at Nottingham—the work of Sir Owen Williams—are evidence of the contribution made by industry to the growth of modern architecture.

Less modern but no less deserving are those buildings of an earlier era which, by virtue of their grace and elegance, are recognised as national treasures. These, industry is helping to preserve. Many stately homes, which might otherwise have fallen into disrepair, have been occupied by industrial firms and research bodies, and used as offices or training establishments. Consequently such fine buildings as Boreham House in Essex, once the home of Warren Hastings and now the Ford Motor Company's Mechanized Farming Centre, continue to be kept in their accustomed style.

Almost any work of architecture can be put to practical use but the appeal of a painting is purely to the eye. Yet even here industry is playing a part. Recently the Shell Petroleum Company invited about 35 British artists, the majority young and not yet widely known, to submit paintings, drawings or lithographs dealing with the oil industry. Otherwise no restrictions were imposed on subject or treatment. A committee including Sir John Rothenstein, director of the Tate Gallery, which had initially advised on the selection of artists, chose works to display at an exhibition, to which painters from abroad also contributed. The entire collection has been purchased by the Shell Company.

If industry is to become a patron of the arts, what can be expected from the artist in return? The Shell Company believes that artists can help to interpret vital industries to the public, and this is a most valuable service in a world where industry plays so dominant a role. Since Leonardo da Vinci there has been little direct contact between art and technology, and the breach between each and the public is at present considerable. Art in many cases has become the esoteric expression of private experience, and industrial technology has for many assumed the character of an ogre.

Interest in industry can be stimulated by the artist, and its activities made more familiar. The artist can often in addition discover qualities that might otherwise be overlooked, and by revealing and enhancing them, show reality in a new, perhaps more pleasing, light. Industry has much to offer the artist, and the dramatic character of its installations, its colour and its movement deserve aesthetic interpretation.

Although the Shell collection includes many works of undoubted merit, it does not perhaps in every case succeed in its intention. Some of the artists have tended to stand apart, to view refineries, storage depots and research centres from outside, approaching their subjects with preconceived ideas. As a result, certain of the paintings evade the issue and do not interpret industry but use it merely as a background or a framework; in a picture of Venice, for example, petroleum storage vessels, which are contrasted with gondolas, are only shown as incidental to the scene. Other artists have chosen to represent gloomy aspects of their subject, perhaps to conform with a view of industry conceived in advance. Nevertheless, many lively impressions of the oil industry have been obtained.

Other industries too might provide interesting subjects for the artist; aircraft construction, shipbuilding and railways are fields only partly covered. Soon perhaps, in order to conjure the appearance of a steam locomotive in rapid motion, it may be necessary to consult Turner's painting, "Rain, Steam and Speed."

An association between art and industry may prove rewarding in many ways and industry has much to offer as both subject and patron. Occasionally there may be minor conflicts, as when the discovery of a Roman temple interrupts a construction programme, but in general both parties must profit. Industry can serve the artist as generously as any Italian prince, and with the artist's help, the gasholders and catalytic crackers of industry may one day seem as picturesque as country cottages.

Weekly Survey

Cover Picture: *In the production of lenses, groups of three or four are mounted together, as shown in the illustration, for smoothing and polishing. The picture shows the examination of a "smoothed" block of three lenses to see if their surfaces are ready for the polishing operation.*

* * *

REBUILDING BRITISH RAILWAYS

"Welcome" and "timely" are two overworked words in journalism. To apply them now to the Transport Commission's plan for modernising and re-equipping British Railways would be an absurd understatement. The plan is the greatest and most heartening proposal that has been made in Britain for many years.

The railways "just grew"; and they have grown into a system which even the traditional loyalty and good service of railwaymen—discouraged by inadequate salaries and wages, and frustrated by restrictions on capital expenditure—have been unable to operate with efficiency. At last it is recognised that the very smallness of this island, and the density of its railway traffic (the highest density in the world), constitute the strongest possible argument for a highly developed railway system. Substantial capital expenditure is more than justified—it is essential. Add to that the neglect of many years, and no one can doubt that Parliament will give its blessing on the plan.

The total expenditure is made up of £210 million for tracks, signalling, etc.; £345 million for the vast extension of Diesel and electric traction; £285 million for passenger vehicles, stations and parcels depots; £365 million for freight wagons and yards; and £35 million for various items, including improvements at packet ports, staff welfare, office mechanisms, and development and research work (requiring a sum of at least £10 million) associated with the plan. The total of £1,240 million is rounded off to £1,200 million.

The plan is based on the premise that its main components shall be capable of being started within five years, and completed within fifteen years. As we noted in Weekly Survey last week, Mr. C. M. Cock, a former railway officer who is now a senior executive in the industry which will be supplying the electric and Diesel plant, is confident that the industry can meet the demands.

WAYS AND WORKS

Major civil-engineering works—including signalling and telecommunications—scheduled under the plan involve an expenditure approaching £450 million. Of this figure, two sums each of £100 million are proposed for the permanent way with its associated structures and for signalling and telecommunications; £80 million for re-sited or reconstructed marshalling yards; £55 million and £50 million for passenger and parcel stations and for goods depots; and another £25 million will be spent on improving facilities at the packet ports and for new and extended office accommodation of personnel.

The greater part of this, perhaps £250 million, represents the value of contracts which will have to be undertaken by civil-engineering and building contractors as the projects materialise over the next twelve to fifteen years. The purpose of the work will be to so strengthen the track and improve the signalling that, on route, heavier trains than run today may safely proceed at speeds up to 100 m.p.h., that both freight and passengers may travel more quickly and the latter more comfortably, and that freight will be handled more quickly through the depots.

The broad first design of these works will have to be undertaken by the Railways themselves, first in order that the results may be in keeping with the overall plan, and secondly so that the form of design will allow construction to proceed without undue interference with traffic operation in any particular area. However, it is specifically stated in the report, that the service of consultants will be sought wherever possible. Armed with a close specification of the form of structure required, it will be the consultants who will be able to prepare the detail designs to take advantage of the latest expedients available from experience in other fields.

ELECTRIC AND DIESEL

"In broad terms," the Commission state, "it is not a question of choosing between electricity and Diesel traction, but rather of combining the two to the best advantage." Electrification will be extended and adopted where traffic density is high; Diesel traction will be used where it is not so high, and for shunting and marshalling. By using Diesel traction it will still be possible to use gas-turbine locomotives if, at some future date, they have been developed sufficiently. By using electric traction, it will likewise be possible to take advantage of atomic power stations if they, too, are developed satisfactorily.

"The Commission accordingly propose to build no new express passenger or suburban steam locomotives after the 1956 programme, and to terminate the building of all new steam locomotives within a few years." The steam locomotive in Britain has been a long time dying, and even now a substantial stock will remain for many years to come. It is fortunate that a very high proportion of the steam locomotives built since the war are of the mixed-traffic type as they will be adaptable to the changing pattern of traffic still hauled by them.

The great extension in the use of electric and Diesel traction will have far-reaching effects on the locomotive works of British Railways. With few exceptions steam locomotives have always been designed by the railways, and new locomotives have been built partly by the railways and partly by the old-established locomotive-building firms, the proportions varying widely over the years. Future policy is as yet unknown but it is almost certain that the export potential of the electric and Diesel locomotive builders will be greatly improved by virtue of the large home demand which they will have to meet.

The plan for freight wagons also involves a fundamental change. By spending £75 million on continuous brakes, the efficiency of British Railways will be raised very considerably in relation to the money involved.

RAILWAY STAFF AND CONSULTANTS

If the plan is implemented it will provide work for many engineering firms, and it will involve a considerable expansion in the present number of the Commission's engineers. There are, we believe, only 400 chartered engineers in the Commission's employ. The need for an increase in the number is recognised in the plan—"an energetic policy of recruitment will have to be adopted"—but there is no mention of salary scales. A committee of the Engineers' Guild has already represented the interests of chartered engineers to the Commission, but although some improvement may be expected, the Commission clearly attach considerable importance to the increased attraction of a railway career in the event of the plan being adopted. "In future," they remark, "the best possible advertisement for a career on the railways should be the plan itself."

Consultants, too, should find added work if the plan is approved, although the Commission state that there are limits to the extensive use of consultants as they must be directed by senior railway staff. Nevertheless, shortage of technical staff to carry out the work will be a serious problem and one of the first requiring solution. The capacity of the engineering industry should be quite equal to the task. Mr. B. H. Leeson, director of the British Electrical and Allied Manufacturers Association, commenting on the plan on the day of publication, said "We can state authoritatively that we have not only all the technical manufacturing resources for the immediate requirements, but also will be able to meet the further demands of the 15-year plan." It will be interesting to see from where opposition to the plan, if any, arises.

* * *

THE NEED TO INVEST

With British Railways proposing a capital expenditure of £1,200 million and the motor industry preparing for an unprecedented scale of investment, the question of priorities in capital investment has suddenly assumed a new importance.

A call to the Government to save and spend wisely in its fiscal policy was made by Mr. D. L. Walker, the general secretary of the Federation of British Industries, in an address to the Scottish members of the F.B.I. last week. He claimed that industry is responding to the incentives given in recent budgets and he called for a continuation of this policy in order that the country's manpower resources can be used to the best advantage.

The scale of investment which is necessary to raise productivity substantially in this country and thus reduce costs was clothed with figures recently in a paper given by Mr. Redfern to the Royal Statistical Society on net investment in fixed assets. He estimates that two-thirds of the gross investment carried out since the war in fixed capital assets in this country has been used for making good depreciation. He estimates that 5 per cent. of the nation's annual output has been devoted in the recent past to net investment of this kind, which gives an annual rate for 1953 of £900 million. Over the years 1948 to 1953, general manufacturing and distribution accounted for only 40 per cent. of the total net figure, the rest being accounted for as follows: housing 35 per cent., public utilities fifteen per cent., public and social services 7 per cent., agriculture 2 per cent., transport and communications 1 per cent. Even this broad classification gives some idea of the way in which investment has been channelled in directions which have the approval of the Government.

For eight years, industry in general and transportation in particular have been starved of capital in order to push ahead with the housing programme and the expansion of electricity generating capacity. The time has come for a change of emphasis and time is running out if a heavy burden of obsolescent plant and heavy transport charges are not to have serious consequences on the prices of British exports.

* * *

INDIAN STEEL CAPACITY

In the last few weeks there has been some clarification of the Indian Government's plans regarding new steel production capacity. It was announced in New Delhi on January 18 that Mr. Nehru, who is travelling to London on January 28, will personally convey India's acceptance of the British offer (mentioned in Weekly Survey for January 7) to the Chancellor of the Exchequer. The chairman of the Indian Steel Plant Negotiating Committee, who is accompanying Mr. Nehru, is expected to start preliminary talks with the United Kingdom steel mission during the visit, and the mission is expected to visit India in March. A capacity of one million tons has been mentioned for the new plant, and in addition it is understood that the British manufacturers will be able to quote for the plant required to extend the capacity of the Tata Iron and Steel Company, Limited, by half a million tons per annum, and for a further half million tons capacity in connection with the new plant now being erected in accordance with the plans drawn up by the German consultants. It is apparently the intention of the Government to double the capacity of this plant from the half million tons already approved to one million tons per annum.

It is believed that negotiations in connection with the Russian offer will be completed by the end of this month and that the Russians will

submit two projects, one for half a million tons capacity and the other for a million tons. It has been stated that they have suggested Bhilai in Madya Pradesh as the site for the plant and consider the larger capacity the more suitable for Indian conditions. If all these developments proceed, the additional capacity will be 3½ million tons per annum, bringing the total Indian steel production capacity up to about 5 million tons per annum. While the official target at the end of the second five-year plan is 4·5 million tons per annum, some Indian Government spokesmen have suggested that 6 million tons per annum will be required.

The fact that expansion is being planned on this scale indicates that the Indian Government are confident of their ability to expand the engineering and other steel using industries in the course of the second five-year plan, and to finance the new factories which will be required. Apart from money raised within the country, the World Bank has already made loans totalling 126 million dols. for development projects in India, while the Industrial Credit and Investment Corporation, Limited, which is being formed by private investors in India, the United Kingdom and the United States to assist the growth of private industry in India, is expected to make long-term and medium-term loans to industrial enterprises, to underwrite new issues and help industry to obtain managerial, technical and administrative advice and assistance.

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OXYGEN AND ORGANISATION

Quick to recognise changed conditions in the field of industrial-oxygen production, British Oxygen Engineering Limited—a recently formed subsidiary of the British Oxygen Company, Limited—has reorganised its administrative structure. In particular, B.O.E. has established a Plant Department to deal with requirements for gas-separation equipment, either for prototype plant with special applications, or for standard installations built to produce liquid and gaseous oxygen.

The Plant Department embraces the development and design functions transferred from the parent Company's Research and Development Department. These activities, together with plant and machine manufacture and inspection, form an integrated group, and projects are thus handled through all stages from inquiry to erection. The Plant Department has a large and expanding programme to meet the demands of world markets, and this calls for increasing numbers of specialists in the fields of chemical, mechanical and instrument engineering.

To house the development, design and construction teams, a modern three-storey office including drawing offices, has been erected at Edmonton. The main plant-erecting and test shop is capable of dealing simultaneously with large plants and components of all sizes required for up-to-date installations, and in the adjacent compressor shop are built and tested air compressors, oxygen compressors and other gas-handling equipment complementary to the main plant items.

An article in this issue describes the large-scale production of industrial oxygen and the plant employed; it gives some indication of the problems encountered by B.O.E.—problems which have called into being the new organisation.

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AGRICULTURAL MACHINERY

The year 1954 was good for British makers of agricultural machinery. Although, as the article in the Engineering Outlook series on page 107 shows, total output was still somewhat below the record level of 1952, it was about 11 per cent. higher than in 1953. The improvement was due mainly to export demand (although home demand also increased) and affected tractors most. Output of such types of equipment as mouldboard ploughs, disc harrows and potato spinners rose very little, and it appears that the market is temporarily saturated as a result of the heavy purchases in 1952. The increase in tractor demand overseas is due partly to the progress which is being made with agricultural development programmes in such markets as the Latin American countries and India, where the huge potential demand for agricultural machinery is just beginning to be tapped. The pace at which the mechanisation of agriculture can proceed in these countries is, however, severely limited by lack of finance and must continue to be slow. Moreover, as soon as sales begin to warrant it there is a tendency for such countries to want to build machinery themselves. Brazil and Argentina for example, are now proposing to make tractors. In Argentina, where the David Brown Corporation are establishing an assembly plant, the Government have also concluded agreements with European manufacturers for the construction of four tractor factories.

Foreign competition is growing in all the world markets and it is thus satisfactory that British exports in 1954 increased in some markets where it was most intense. Particularly notable was the achievement of increasing exports to the United States, which is now the second largest market for British tractors. The Ford Motor Company, who are largely responsible for the success, claim that they can market a British-built Diesel tractor in the United States more cheaply than their American associates can market an equivalent petrol model.

Sales of implements which have been specifically designed for use with particular makes of tractors have been better than for other types, and the trend towards integrally designed implements and tractors has been accentuated. A "Ford" farming system is now being built up to compete with the rival "Ferguson, System," and Ransomes Sims & Jefferies, Limited, who manufacture the implements, are doubling their capacity. Such systems of integrally designed implements have much to commend them and their commercial advantages are obvious, but a stage has now been reached where manufacturers are in danger of neglecting the best interests of consumers unless they can introduce some standardisation to give interchangeability of implements between different makes of tractors.

The outlook for the current year is fair enough, although the bad harvest last year (which was not confined to the United Kingdom) reduced farm incomes. At home, the agricultural price structure and systems of deficiency payments provide some incentive for mechanisation, while the increase in depreciation allowances last year makes it easier for the farmer to pay for new equipment. Abroad, with greater stability and possible improvement in world prices, agricultural incomes should be higher.

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TURBO-PROPS FOR EXPORT?

As a private venture, D. Napier and Son, Limited, Acton, W.3, are tooling up at their Liverpool factory for the production of Eland propeller turbines, which it is expected will be coming off the line before the end of 1955. It is anticipated that there will be a wide demand for engines of the 3,000-h.p. class, and the Eland, at present rated at 3,000/3,250 h.p., has at present no competitors. The success of the Viscount air liner has stimulated the interest of air-line operators and aircraft manufacturers throughout the world in the propeller-turbine engine, and in particular the United States has, within the last year, suddenly been made aware of its potentialities for civil operations. Representatives of the Napier company report that the Lockheed, Douglas and Consolidated Vultee companies all have design studies for aircraft based on the Eland engine. The world-wide sales and servicing facilities of the English Electric Group, of which Napier are a member firm, will be available to all purchasers of Napier engines.

It has been the policy of the Napier company to develop each major component of the engine separately and an incidental result of this policy is that it makes possible the rapid interchange of such components, thereby facilitating maintenance and rationalising stores holdings. The company have been notably successful in developing a compressor with a high pressure ratio which has excellent characteristics over the whole working range. Thus it has been possible to obtain good performance and economical fuel consumption without resorting to the complication of a "two-spool" layout. Another characteristic of the Napier engine which is generally viewed favourably by operators is the absence of electronic controls, a fully automatic mechanical/hydraulic single-lever control being employed, providing all necessary safeguards in the event of engine failure.

As announced recently, the Napier company are to fit two Elands in a pre-production Ambassador aircraft lent by the Ministry of Supply, and they have themselves purchased a Convairliner 340 for conversion to Eland power plants. Both these aircraft should be converted and flying by the middle of the summer, and it is intended to obtain Certificates of Airworthiness for them and then to gain experience with them in ordinary commercial passenger operations. The Eland-Convair 340 will then be made available for world-wide demonstration, and it is believed that many operators of the Convair 340, now obsolescent, will thus be attracted by the superior cruising speed—an increase of 60 m.p.h. is expected—and economy into undertaking the conversion of their fleets.

Now under development is a higher-powered version of the Eland to develop 4,000/4,200 e.h.p. This engine will incorporate the existing proved axial compressor and combustion system, and the reduction gear which has already been type-tested under 4,000 e.h.p. The increase in power will be obtained by a re-designed cooled turbine designed to work at a higher inlet temperature and which has been running on the testbed now for some months. It is expected that the 4,000-h.p. Eland will be in full production by the middle of 1957, by which time this engine also will have had the opportunity of proving its capabilities when installed in the Convair liner.

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NATURAL AND SYNTHETIC FIBRES

With the coming into production of the Terylene plant of the Imperial Chemical Industries, Limited, at Wilton, another synthetic fibre will begin to find its place in the textile and industrial world. Although output from the pilot plant has been on the market for some little time, the quantity was only small, being about two million lb. a year. It is estimated that the new plant will be able to produce at about ten times this rate when the second unit is complete. Although this will be an appreciable amount, it is still small compared with the total of synthetic fibres now being manufactured said to amount to some 400 million lb. Even this is smaller, though not by very much, than the quantity of wool used in this country last year—about 450 million lb. This in turn is exceeded by cotton yarn production which has been estimated to run at about 900 million lb. a year.

However, in spite of its relatively small availability, Terylene will find its part to play where its particular properties are of special value, just in the same way that other synthetic fibres have done and, indeed, are still doing. The plant at Wilton has been laid out to give a steady flow of material with a minimum of handling, an arrangement which should keep overheads within reason. The raw materials are already being made by the Billingham division of I.C.I., separated from Wilton by only a short distance and already connnected by pipe lines. Thus production will be almost independent of transport costs. Elsewhere in this issue a brief account of the plant is given and some of the present uses of Terylene described.

HOW MANY MOTOR VEHICLES BY 1960?

THE UNKNOWNS IN A SIGNIFICANT EQUATION

Recent pronouncements by the leading motor-car manufacturers about their investment plans envisage a 50 per cent. increase in the number of cars to be manufactured in this country by the end of the next five years. During 1954, just over one million passenger and commercial vehicles were made in British factories, so that by 1960 the number may be over 1½ million. This substantial increase will be taking place at the same time as that of the growing continental industry. It has been estimated that by 1960 German production will have reached between ¾ and 1 million, French ¾ million, and Italian ½ million, making a total European production of between 3 and 3½ million cars. During the next few years the American manufacturers may become more interested in exports and their Government may well bring pressure on other countries to admit more American cars as part of the President's more liberal trade policy. The British Government's recent decision to increase the quota of American cars imported into this country may be a straw in the wind.

In addition to these substantial increases of supply from the main manufacturing countries to world markets, new productive facilities are being created in some of the markets for British cars, notably in Australia, India and South America. So far there have been negligible exports from the Iron Curtain countries, though these should not be discounted in the future, particularly from Czechoslovakia. The possibility of increased British exports will, therefore, depend on an expanding world market even more than on their competiveness. Undoubtedly, it is going to expand over the next half of the century, but the pace of this expansion will largely depend on the rate at which living standards grow in the poorer countries. In the early stages of industrialisation of under-developed countries, although the percentage increase of purchase of motor cars may be very high, the absolute increase will not be very great.

DROP IN EXPORTS SINCE 1950

Exports last year at just under 500,000, including about 120,000 commercial vehicles, have not yet reached the peak 1950 figures. It has been suggested that half the increased output will be sold abroad; an increase of 250,000. A more likely figure, in view of the growing competition, is 100,000. If exports are somewhere between the two, between 250,000 and 400,000 more cars will have to be sold in the home market. Is this possible.?

Taking commercial vehicles first, home sales have been levelling off over the last two or three years at about 120,000 a year. The actual number of replacements is not accurately known, but is believed—over the last five or six years—to have averaged 50–60,000 a year. The numbers are rising and had probably reached 90,000 last year and may be expected to increase a further 30,000 over the next five years. Total home sales of commercial vehicles can, therefore, be expected to reach 150,000. The picture by 1960 would then look something like this:

Production (all types).	Sales.	
1,500,000	Exports (all types) ..	600,000—750,000
	Home Sales (commercial)	150,000
	Home Sales (passenger) ..	750,000—600,000
		1,500,000

The figure for home sales of passenger cars is a balancing figure and it is the one on which all the manufacturers' plans must ultimately depend. Here again, one of the most difficult figures to estimate is the future rate of replacement. It appears that over the last few years, in spite of the incentive of the initial allowance, the average rate of replacement of passenger cars has been amazingly low; but it has been rising very steadily and last year was probably between 50,000 and 60,000. If this trend continues it will reach 100,000 by 1960, which would leave between 500,000 and 650,000 to be sold to new car owners or that very small number of owners increasing a fleet of cars or buying a second one for their wives.

This is a pretty formidable figure and it will require a substantial increase in wages and salaries over the next few years to make it possible. Buying a car is not a once and for all proposition, like buying furniture, and the deciding factor in whether or not a car is bought is the running cost, which will include, in the case of most new purchasers, the hire-purchase charge. The question is, therefore, how many cars should there be on the road by 1960 if these plans are to be carried out, and will there be enough people who can afford to run them.

If new registrations took place at the rate indicated by the above figures there would be between 2,125,000 and 2,500,000 new passenger cars on the road by 1960, in addition to approximately 3,100,000 to-day; a total of between 5,225,000 and 5,600,000. In a recent article in the *Economist* it was estimated that this figure of car users would be possible on three conditions: (1) that average incomes between £250 and £1,000 a year were 20 per cent. higher; (2) the list price inclusive of purchase tax at to-day's rate would have to be between £225 and £250; (3) all taxes on motoring would have to be halved. The last condition might well be a fiscal possibility, if the first two could be fulfilled; but can prices (and, presumably therefore, costs) be so reduced? To-day the average price before purchase tax of the five cheapest British cars is £342 and, with purchase tax, it is nearly £500. It looks, therefore, as if a 50 per cent. increase of output would have to produce an equivalent decrease in costs for sales of this magnitude to be possible. Raw material prices are hardly likely to fall during this period; the industry's manufacturing methods are not likely to undergo a revolution on a sufficient scale; and the reduction of overheads per unit consequent on the higher output would clearly by itself be inadequate. The only possibility would be still further concentration of manufacture on a design so radical as to change all previous conceptions of cost, but for that purpose the industry would have to spend far more than it does on research and the employment of trained scientists and technologists. The amount spent by the separate companies for this purpose is not known, but the £100,000 income of the Motor Industry Research Association is very small by comparison with the value of the industry's turnover.

STEEL AND ROADS

The importance of the decisions which the industry is taking are best judged in relation to their consequent effects in other sectors of the economy. The steel industry is known to be anxious about the future level of demand for steel sheet, which has been rising rapidly both on account of demand from the motor industry and for domestic appliances. During 1954 imports of sheets rose in the first eleven months from an average of 1,000 to 14,000 tons a month. An increase of half a million cars will alone absorb over 300,000 tons; the minimum economic capacity of a modern wide strip mill is one million tons a year and its cost, with all its ancillary iron and steel-making facilities, is about £100 million. The accessory manufacturers have stated that they will follow the main manufacturers by spending £100 million on increased production facilities and, presumably, tyre makers will have to follow suit.

Finally, if we are indeed to have 7,000,000 vehicles (including commercial vehicles) by 1960 a major programme of road building will be essential. At nineteen vehicles per mile, Britain already has the most congested roads in the world and the cost of accommodating more cars in our towns is likely to be very high indeed. The total investment required may well be in the region of £700 million, or £140 million a year, which is roughly a third of the total net investment in fixed capital, excluding housing, in 1953.

OIL-REFINING CAPACITY

On the other hand, an increase of this order in the number of cars in use will not necessitate new oil-refining capacity. Already, owing to the growing use of fuel oil, the oil companies are becoming embarrassed by a surplus of refined grades, a situation which might, however, be rectified by exchange with the United States, where the situation is reversed.

Investment on this scale must be considered in relation to the total investment required of the British economy over the next five or ten years. Very substantial programmes have been announced by the electricity and gas industries, and the British Transport Commission have prepared a plan to spend £1,200 million over a period of 15 years on the modernisation of the railways. In view of the still precarious nature of the balance of our overseas accounts, investment is still most needed in those industries with growing export potentials. The motor industry's capital expenditure must to some extent compete with the needs of these industries for plant and equipment. It must, therefore, be judged by whether, after account has been taken of its effect on other export industries and of the resultant increased requirements of imported raw materials and labour, it betters or worsens our balance of payments with the outside world.

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Letters to the Editor

A LOCAL INFORMATION SERVICE

Technical College Libraries Help Industrial Firms

SIR, Your leading article last week ignores a factor which is indeed rarely considered when co-operation between industry and technical education is mooted—the service rendered by the technical college library.

In the past this was understandable as there were few such libraries in existence, but since the war there has been a steady increase in establishment though there are still many ill-equipped to meet the needs of the college, let alone industry. It is strange that Government and industrial information services have lamented the feeble use of the service they provide but have rarely shown any appreciation that men who are the "backbone of industry," trained in technical colleges, have in the past finished their training with no experience in how to use information services or carry out a logical search of technical literature.

Since the war there have been many suggestions for promoting and assisting the dissemination of information to industry. Many public libraries have tried to assist but there has been no mention of the part the good technical college library can, and indeed is, playing in the task. It is a great pity more attention is not given to promoting this co-operation, particularly in the provincial towns where the technical college should rightly house the information centre and service for local industry.

Yours faithfully,
GORDON H. WRIGHT.

Greenway-court,
Hollingbourne,
Kent.
January 21, 1955.

Obituary

DR. HERBERT CHATLEY

Engineer, Linguist and Antiquarian

It is with a keen sense of personal loss that we record the death, after a comparatively short illness, of Dr. Herbert Chatley, M.I.C.E., formerly chief engineer of the Whangpoo Conservancy Board, Shanghai; not only a civil engineer of unusually wide experience, but professor, scientist, linguist, antiquarian, and a valued contributor to ENGINEERING for nearly 47 years. He was taken ill in November last, only a few days before he was to have delivered to the Newcomen Society a paper on "Far Eastern Engineering"—the last of more than 200 that he wrote in the course of his life. He died at Gloucester on January 17, in his 69th year.

Dr. Chatley was born on May 17, 1885, and received his general education at Cambridge House School, in North London. On leaving school he entered the office of a consulting sanitary engineer, Mr. Arthur Tigue, but shortly afterwards secured a position in that of Mr. Francis Wood, M.I.C.E., then borough engineer to the Fulham Borough Council, with whom he remained from 1902 to 1906. In the evenings he attended classes at the Northern Polytechnic, studying civil and mechanical engineering subjects, and in 1906 received from the University of London the external degree of B.Sc. (Eng.). Thus qualified, he went to Portsmouth Municipal College as lecturer in civil engineering, remaining there until 1909 when, though still only 24 years of age, he was appointed Professor of Civil Engineering in the Chinese Government's engineering college at Tongshan, North China.

He continued at Tongshan until 1915, when he was appointed assistant engineer, and shortly afterwards district engineer, to the Nanking-Hunan Railway, for which he carried out surveys extending over some 2,000 miles. In the following year he joined the Whangpoo Conservancy Board as engineering assistant under Mr. H. von Heidenstam, M.I.C.E., undertaking important dredging works and making valuable studies of the nature and behaviour of the mud and silt—in places more than 700 ft. deep—in the Whangpoo and Yangtse estuaries. He succeeded von Heidenstam as engineer-in-chief in 1928, retiring from that position in 1937; but he continued to act as consultant to the Board and to other Chinese river authorities until 1940, with an office in London. In that year he joined the department of the Civil Engineer to the Admiralty as superintending civil engineer, in which capacity he was closely concerned with the Mulberry Harbour works for the Normandy landing. He left the Admiralty service in 1946 and resumed consulting practice, in which he was engaged until a short time before his death.

Dr. Chatley, whose degree of D.Sc. (Eng.) was conferred upon him by London University in 1914 for research on rolling friction and convex contact, was a member of the Institution of Civil Engineers (to which he had been admitted as an associate member in 1920) and of the Institution of Civil Engineers (Ireland). He was also a Fellow of the Physical Society, an associate of the Institute of Physics, a former chairman of the Junior Institution of Engineers, and a member of several other engineering and scientific societies, including the Newcomen Society, to which he contributed some scholarly papers on early Chinese engineering. For many years, he took a keen interest in the problems of mechanical flight and it was in a discussion on this subject in our columns that he made what we believe to be his first contribution to ENGINEERING—a Letter to the Editor, published in our issue of February 7, 1908, in which he modestly stated that he had "given a little attention to this subject for some years." He was then 22, but he justified the claim on the evening of that same day, when he read a paper on "Aerial Navigation" before the Junior Institution of Engineers. His paper was well received and highly praised by an audience which included many who were already distinguished in aeronautical engineering and science.

Throughout his life, Chatley was a voluminous writer, mostly of institution papers and contributions to the technical Press, but he also produced a number of small books in his younger days, on the problems of flight, stresses in masonry, railway engineering, water and wind power, and molecular forces. On four occasions he was awarded a Telford Premium by the Institution of Civil Engineers, the first being in 1920 for a paper on "Silt" and the second, in 1928, for one on "Problems in the Theory of River Engineering." The third and fourth, in 1939-40 and 1944-5, respectively, were for papers dealing with dredging, especially drag-suction dredging, his last work for the Whangpoo Conservancy having been to design, and superintend the construction of, a drag-suction dredger, the Fu-Shing, the largest of her type and the second largest dredger ever built. This vessel was fully described and illustrated in our 146th volume (1938), but never took up her intended service. She was built by the German firm of F. Schichau G.m.b.H., at Elbing, and could not be delivered to the Whangpoo because of the outbreak of war. Of her eventual fate we have no details. On his retirement from the Whangpoo Conservancy Board, Dr. Chatley was honoured by the President of the Chinese Republic with the Order of the Brilliant Jade; and for his work during the recent war, while with the British Admiralty, the French Government made him an Officer of the Legion of Honour.

A stimulating conversationalist on a great diversity of subjects, Dr. Chatley was almost as fluent in French, German and Chinese as in English, and had more than a superficial acquaintance with several other languages, ancient and modern. For a number of years he had made his home in Bath, whither he had gone initially to take up his Admiralty appointment and where he found congenial occupation, in eventual semi-retirement, in studying Roman archaeology and comparing the development of Roman engineering and constructional practice with that of the corresponding periods in China, with which he was so familiar. A man with such varied interests naturally acquired many friends, by whom he will be greatly missed.

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We regret also to record the deaths of:

MR. JAMES KENDRICK BRADSHAW, on December 28, 1954, at the age of 63. He had been works engineer at the Fort Dunlop plant of the Dunlop Rubber Co. Ltd., since 1946. He joined the firm at Fort Dunlop in 1925 as a power-plant shift engineer and seven years later became chief assistant and maintenance engineer.

MR. ROBERT GREENWOOD, at his home on January 15. He was a director and works manager of Greenwood's Standard Gear Cutting Co. Ltd., New Bond-street, Halifax, Yorkshire.

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PERSONAL

MR. K. J. COOK, O.B.E., M.I.Mech.E., is to be President of the Institution of Locomotive Engineers, 28 Victoria-street, London, S.W.1, for the season 1955-56. He will take office as from June 1.

MR. R. P. MORISON, Q.C., has been appointed independent chairman of the Executive Committee of the British Iron and Steel Federation, Steel House, Tothill-street, London, S.W.1, in succession to the late MR. FREDERICK GRANT, M.C., Q.C.

SIR RICHARD ERNEST YEABSLEY, C.B.E., F.C.A., has been appointed a director of the Ruberoid Co. Ltd., manufacturers of bituminous building materials, Commonwealth House, 1-19 New Oxford-street, London, W.C.1.

The services of MR. J. F. FIELD, B.Sc.(Edin.), M.I.E.E., M.I.C.E., M.I.Mech.E., controller of the South-East Scotland Division of the British Electricity Authority, are to be retained by the Authority when the Division is taken over by the newly-established South of Scotland Electricity Board on April 1. Mr. Field will be employed initially in the Authority's headquarters engineering department, under the chief engineer, on special duties connected with the development of plant and equipment to operate on the Field Cycle.

MR. N. F. PATTERSON, director and general manager of production, Monsanto Chemicals Ltd., 8 Waterloo-place, London, S.W.1, has been appointed operations director responsible for all manufacturing operations of the company.

MR. W. CARDNO has been appointed agent in charge of the construction of the Auckland Harbour Bridge, New Zealand, the contract for which was last year placed jointly with the Cleveland Bridge & Engineering Co. Ltd. and Dorman Long (Bridge and Engineering) Ltd.

MR. G. E. H. HALL, A.M.I.P.E., has been appointed a director of Sheepbridge Stokes Ltd., and of British Van der Horst Ltd., Chesterfield. MR. R. GORE, A.M.I.Mech.E., A.M.I.P.E., is now general manager of the Engineering Division of Sheepbridge Equipment Ltd. MR. C. HAND has been appointed general manager of the Foundry Division of Sheepbridge Equipment Ltd. MR. J. R. JENKINS has been made methods engineer for the Southern group of Sheepbridge companies. MR. E. A. MACDONELL is now Southern Area sales representative for Automotive Engineering Ltd., Twickenham, and MR. F. W. SIMMONS, manager of the London branch of Sheepbridge Engine Repairs Ltd.

MR. E. G. FLETCHER, shipyard manager with William Doxford and Sons Ltd., Sunderland, has retired after 45 years of service with the firm. He was chief draughtsman, shipyard department, before being appointed yard manager in 1941.

MR. C. G. PULLIN, F.R.Ae.S., M.I.Mech.E., has been appointed a director and technical consultant of Winget Ltd. MR. NORMAN STAFF, J.P., A.C.A., secretary of the firm, has also been appointed to the board.

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COMMERCIAL

THOS. W. WARD LTD., Albion Works, Sheffield, have taken control of George Hassall Ltd., machinery merchants and steel stockholders, Cobridge, Stoke-on-Trent. MR. S. J. DYAL and MR. H. VERNON (both directors of Thos. W. Ward) have been elected to the board of Messrs. Hassall, while MR. R. DEAVILLE remains as resident director.

A new company, J. A. DAVIES (STEEL) LTD., 67, Becklow-road, Hammersmith, London, W.12, has been formed to deal in ferrous and non-ferrous metal scrap and to act as stockholders for the supply of sheets and other constructional materials. The chief executive officer of the new company is MR. J. A. DAVIES, until recently manager of Cox and Danks Ltd., Park Royal, who in the spring of last year became President of the London and Southern Scrap Iron and Non-Ferrous Metal Merchants' Association.

THE RHEOSTATIC CO., LTD., Slough, Buckinghamshire, have decided to dispose of the portion of their business connected with the manufacture of resistors for use with heavy electrical equipment. Negotiations are almost complete for METAL INDUSTRIES LTD., to take over this part of their business as from April 1. The IGRANIC ELECTRIC CO. LTD., Bedford, one of the Metal Industries group of companies, will then make themselves responsible for the completion of all outstanding orders for such resistors. The Rheostatic Co. will then concentrate their attention on the production of "Satchwell" thermostats and temperature controls.

METAL INDUSTRIES LTD., have announced the formation of a new subsidiary company, METIND LTD., which will operate from a new factory to be constructed in the Bromborough area. The new factory will initially undertake work of a repetitive nature for other member companies in the group. MR. K. N. SWASH has been appointed chairman and managing director. The other directors are MR. F. R. LIVOCK and MR. T. D. TURNER. Metal Industries Ltd. also announce that they have acquired the whole issued share capital of FINNEY PRESSES LTD., Berkley-street, Birmingham. The activities of this company will be co-ordinated with those of another member of the Metal Industries Group, FAWCETT, PRESTON & CO., LTD. The directors of the newly-constituted company are MR. J. BLACK, chairman; MR. J. TREVOR-JONES, manager; and MR. L. DAVIES.

SHEEPBRIDGE ENGINEERING LTD., Chesterfield, by arrangement with MAHLE-K.G., Germany, have secured the sole United Kingdom manufacturing and selling rights for a process for depositing hard chromium directly on to aluminium-alloy engine cylinders and similar components. BRITISH VAN DER HORST LTD., a subsidiary company of Sheepbridge Engineering Ltd., will operate the process.

ENGINEERING IN THE PLAN FOR BRITISH RAILWAYS

The work involved in the £1,200 million plan for modernising and re-equipping British Railways is virtually all engineering. The following abstract of the British Transport Commission's report concentrates, therefore, on the engineering aspects, with brief references to financial and staff considerations. Plant and equipment of the following types are embraced by the plan: track, signalling, telecommunications, electric and Diesel locomotives and rolling stock (with appropriate maintenance depots and equipment), track-electrification, equipment, station and parcels-depot equipment, wagons, continuous brakes (vacuum) and couplings for wagons, marshalling yards, wagon loading and unloading appliances, motor road vehicles, improvements at the packet ports, and office equipment (including electronic computers). The work, which it is intended should be started within five years, and completed, for the most part, within fifteen years, will clearly have favourable repercussions, direct and indirect, on practically all British engineering industries. This abstract should be read in conjunction with the Weekly Survey notes in this issue, which give the general strategy of the plan together with editorial comment.

CIVIL ENGINEERING

Although the main trunk lines were constructed over a century ago, their engineering standards are still high, and though many routes between important centres were built during the great period of inter-railway competition, with some overlapping in consequence, as a whole, they were well planned in respect of traffic flow, and in this respect they still broadly meet the requirements of this century. The need to improve the permanent way and structures, however, falls under several headings.

First, renewal of bridges: current reconstruction has not been adequate and during the next 20 years the rate of replacement must be greatly accelerated in order to prevent the dislocation of traffic which would otherwise occur with the simultaneous life-expiry or weakening of a large number of bridges. Over the period of the plan, £20 million has been allocated for this work of bridge replacement, over and above current expenditure.

Secondly, track alignment: train operation is at present handicapped by permanent speed restrictions imposed by sharp curves, junctions and other inadequate track facilities, and a sum of £25 million is estimated to be required for improvements in these respects. The aim is to achieve speeds of at least 100 m.p.h. on the main lines.

Thirdly, track stability: changes in forms of motive power, the increased speed of movement and weight of trains will necessitate the strengthening of the track structure by re-ballasting and stabilisation of the sub-grades. This work is expected to cost £35 million.

Finally, a further £25 million will be required for new lines, improvements to layout and the provision of flyover junctions, etc., to meet projected developments of industry. In all, the cost of the aforementioned improvements to the track and its associated structures is £105 million. Moreover, works to the gross value of £200 million, as detailed later, is proposed in respect of yards, stations and depot facilities, and of the packet ports.

SIGNALLING AND TELECOMMUNICATIONS

The faster and more intensive services will require substantial investment in modern methods of controlling traffic. Provision must be made for the widespread replacement of semaphore signals by colour-light signalling, which is to be mainly automatic in operation. There must also be a considerable extension of track circuiting, whereby movements of trains are automatically indicated to the signalman and appropriate safeguards applied. The provision of power-operated signal boxes in replacement of the mechanical operation of points and signals will be widely extended; one modern power box will replace several manual boxes.

Centralised traffic control will be further applied to British Railways. This makes possible the operations from a central control of all the points and signals over lengthy route-mileages and offers marked advantages over conventional methods of signals, where conditions are favourable to its use. An expenditure of £20 million has been estimated as the cost of the progressive introduction of automatic train control throughout the system.

Efficient telecommunications also constitute a vital service for the railways. The existing telegraph and telephone systems must be considerably modernised, and advantage taken of all available developments in telecommunications.

The estimated expenditure for signalling and telecommunications, including A.T.C., amounts to £100 million. With an allowance of £5 million for sundry items, the total for the part of the Plan dealing with Ways and Works, Signals and Communications, amounts in all to £210 million.

MOTIVE POWER

The Commission have decided that major changes in the forms of motive power on British Railways must be effected, involving a widespread changeover from steam to electricity and Diesel power. They accordingly propose to build no new express passenger or suburban steam locomotives after the 1956 programme, and to terminate the building of all new steam locomotives within a few years.

The main scope for development at present rests with electricity and Diesel traction. In many ways electricity is the ideal, since it meets the requirements of reliability, good acceleration, cleanliness and (where the traffic is sufficiently heavy) economy in operation.

The main disadvantage of electrification is that it frequently involves substantial engineering works on track and structures, signalling and telecommunications. A further consideration is that in some cases in the past the riding qualities of electric multiple-unit stock have not equalled those of modern vehicles hauled by a separate locomotive. Research has, however, been undertaken into the design of bogies for electric multiple-unit vehicles, and it is confidently expected that future designs will provide an entirely satisfactory standard of passenger comfort.

Diesel traction offers many of the advantages of electricity in the shape of cleanliness, acceleration and uniform standard of performance. It has a further advantage in that the changeover from steam to Diesel working generally does not involve important civil engineering or signalling works. On the other hand, on the lines of heaviest traffic the potential economies are less with Diesel traction than with electrification. The present cost of a Diesel locomotive is about two-and-a-half to three times that of a steam locomotive of equivalent power and, to yield economic results, Diesel locomotives must achieve a very high degree of utilisation.

The use of atomic power in relation to railways seems likely to be indirect, namely through the use of nuclear energy at electric power stations, rather than through the development of atomic-powered locomotives. The extension of railway electrification will enable the Commission to take advantage of the introduction of atomic power.

In broad terms, it is not a question of choosing between electricity and Diesel traction, but rather of combining the two to the best advantage. The plan is flexible enough to enable advantage to be taken of any technical developments, including gas-turbine propulsion, that may become available.

ELECTRIFICATION

At the moment, work is proceeding with the extension of the Liverpool Street-Shenfield electrification to Chelmsford and Southend (Victoria). Various other schemes have been under consideration, and planning upon them has reached different stages of development. It is proposed that under the plan all these schemes should be adopted.

In addition, it has always been the intention that, as soon as circumstances permit, all the main routes of the Southern Region east of a line drawn from Reading to Portsmouth should be electrified. This will extend to the coast the electrified zone which now terminates at Gillingham, Maidstone and Sevenoaks, and carry the electric train services to Ramsgate, Dover, Folkestone and (via Ashford) to Hastings. In conjunction with the Diesel services to be introduced, this will affect the elimination of steam traction from all the lines of the Southern Region in the area mentioned.

This programme will entail electrifying about 250 route miles of line at a cost of approximately £25 million for the fixed equipment.

It is the intention to electrify two major trunk routes, and one of lesser traffic density. The main line of the Eastern and North Eastern Regions from King's Cross to Doncaster, Leeds and (possibly) York, and the main line of the London Midland Region from Euston to Birmingham, Crewe, Liverpool and Manchester, will comprise the two major schemes. The subsidiary main-line scheme will consist of the extension of the existing electrification from Liverpool Street (which will soon reach Chelmsford) to Ipswich, including the Clacton, Harwich and Felixstowe branches. By these schemes there will be a virtual elimination of steam from important areas of the country.

The estimated cost of the fixed installations for all these schemes is around £125 million, and the cost of some 1,100 electric main-line locomotives will be about £60 million. This represents a very large programme; and the Commission are taking expert advice as to the capacity of the available technical staff and of the electrical manufacturing industry to carry it out. Should it appear necessary to limit the programme, one of the main routes concerned would in the meantime be converted to Diesel traction—without prejudice to its eventual electrification.

DIESEL TRACTION

It is now accepted that, where the traffic is within their capacity, a considerable improvement in net revenue can be secured from the replacement of steam services by Diesel-powered trains, ranging from single units to six-coach trains. A start has already been made with the introduction of this type of train.

Under the plan a much wider extension of Diesel multiple-unit working is envisaged. This will include three principal types of service: city-to-city express services; secondary and cross-country routes; and branch lines. The total number of multiple-unit Diesel vehicles that can be employed on British Railways for these services is estimated at about 4,600, including the 300 now in use or on order.

The present programme for the construction of Diesel shunting units in replacement of steam locomotives will be completed in 1957, and a further programme is in course of preparation. It is considered that the complete elimination of shunting and trip working by steam locomotives should be achieved over the next fifteen years. The total number of steam locomotives that will be displaced by this conversion is approximately 1,500. They will be replaced by about 1,200 Diesel locomotives, additional to those already authorised, at a total cost of about £25 million.

Diesel traction, then, may be regarded as a half-way house to electrification. A very substantial investment is proposed in Diesel main-line locomotives, commencing forthwith, with the object of achieving as soon as possible a complete changeover from steam to Diesel traction in specified areas. It is intended to standardise design as much as possible.

By the end of the period covered by the plan about 2,500 main-line Diesel locomotives should be in use. For example, on the Western Region it is intended to eliminate all steam working beyond Newton Abbot and also to employ Diesel units based in that area for hauling a large proportion of the passenger and freight trains from the West to London and Bristol and back. On the Southern Region the greatest early advantage will be secured by employing Diesel locomotives to replace steam services between Waterloo and Exeter, and Waterloo, Southampton, Bournemouth and Weymouth. In these two schemes some 200 main-line Diesel locomotives will be required, which will displace over 300 steam locomotives. Changes to Diesel traction in other areas will be progressively effected.

The total cost of the main-line Diesel locomotives to be built under the plan is £125 million.

The total expenditure proposed on new methods of traction can be set out as follows :—

Total Expenditure on New Methods of Traction (£ million)

—	Structures, etc.	Locomotives and rolling stock	Total
Electrification—			
Main lines			
London Midland Region	40	35*	75
Eastern Region	20	25*	45
Total main lines ..	60	60*	120
Suburban lines	40	*	40
Southern Region extensions	25	*	25
Diesel traction—			
Main-line locomotives ..	—	125	125
Multiple-unit trains ..	—	*	*
Shunting and trip locomotives	—	25	25
Steam motive-power depots	10	—	10
Total	135	210	345

* Multiple-unit vehicles, whether electric or Diesel, have been taken into account under "passenger carriages."

As regards steam motive-power depots, many of these require to be rebuilt or substantially modernised; and if no change in the present types of motive power were contemplated there is no doubt that a considerable expenditure would have to be incurred

on essential improvements. In view of the proposals here referred to, however, all schemes for the provision or modernisation of depots designed to service steam locomotives will need to be re-examined in the light of the new developments. The maximum financial advantage is to be secured where it is possible to effect a complete changeover in the form of motive power, but some capital expenditure on steam depots will be inescapable to meet essential requirements, particularly at large freight depots. It is estimated that a sum of £10 million should cover the expenditure on steam motive-power depots.

PASSENGER TRAFFIC

It has been thought right to include a substantial sum for the reconstruction of passenger and parcels stations. Improvements at many major stations will involve new methods of parcels handling and its segregation from the other work of the station. A programme for carriage-cleaning and servicing depots has also been prepared. The total expenditure upon passenger and parcels stations and carriage-cleaning and service depots is estimated at £55 million.

British Railways have 42,000 passenger-carrying vehicles. The plan provides for important changes in the total number and types.

In the first place, the changes in motive power will involve a large carriage-building programme, since many steam-hauled vehicles will be replaced by multiple-unit Diesel or electric vehicles. Secondly, it is expected that some reduction in the total stock will be achieved through more intensive use. Next, the changing requirements of the public, and the higher standards of amenity that will be expected, will influence the building programmes. Lastly, the study of comparative costs of different types of passenger service has revealed that certain stopping and branch-line steam services are carried on at a heavy loss. For the most part the carriages employed are of the non-corridor compartment type. Broadly speaking, these services will either be replaced by Diesel multiple-unit trains (which will normally be the case where there is a reasonable prospect of stimulating sufficient additional traffic), or by road services.

So far as changes in motive power are concerned, the main-line and suburban electrification schemes, including the extensions in the Southern Region, will involve the construction of some 3,600 multiple-unit electric vehicles. The total number of multiple-unit Diesel vehicles required is about 4,600. After taking account of all the factors listed above, it is estimated that the total required stock of passenger-carrying vehicles is some 36,000 vehicles. This compares with a present figure of around 42,000. Over the period of the plan, the total number of new passenger carriages to be built will be about 31,000, at a cost of approximately £230 million.

MARSHALLING YARDS AND GOODS STATIONS

Rational methods of operating require the elimination of many old marshalling yards and their replacement by a smaller number of modern yards. A survey has therefore been made of the scope for resiting and modernising marshalling yards. The plan provides for the construction or reconstruction of some 55 marshalling yards, which would result in the total or partial closure of about 150 existing yards. It is estimated that these proposals would cost about £80 million.

The introduction of modern methods of handling goods is an important component in quicker and more punctual freight service. It will be necessary to close various old depots and concentrate their work in a smaller number of large modern depots. This will reduce shunting and "trip" working of trains, improve transits and concentrate sufficient tonnage at stations to justify capital expenditure on mechanical handling appliances. These depots will be so constructed as to provide for the expeditious exchange of full-load traffic between road and rail. The total cost for new and reconstructed goods stations is £50 million. Associated with the improvements at freight terminals there will be requirements for cranes and other mechanical handling devices; additional collection and delivery road vehicles; and improved repair and maintenance depots for road vehicles. The additional expenditure involved for these items will be of the order of £10 million.

CONTINUOUS BRAKES FOR WAGONS

A high proportion of the costs of railway operation is related to time rather than to distance. Accordingly, higher speeds of movement can often achieve major economies and increase the productivity both of the labour and of the capital assets employed. Great Britain is the only major industrial nation in which a large proportion of the freight traffic is still carried in loose-coupled wagons not fitted with continuous brakes. The absence of continuous brakes necessitates slow timings and, consequently, undue occupation of the track. The chief advantages of fitting continuous brakes are increased line capacity for all services, passenger and freight, because of more uniform speeds; better transit times for freight traffic; improved punctuality; and greater safety in train movement.

In the running of unbraked trains, the railways must provide catch points upon gradients more severe than 1 in 260. Continuous brakes would enable these points to be dispensed with, and eliminate the delays and expense that arise through having to use these safeguards. There are approximately 1,000 places on British Railways where wagon brakes must be pinned down before trains proceed over severe falling gradients. The total time occupied in carrying out this regulation is about 10,000 hours a week.

The higher average speeds of train movement and the better punctuality will lead to a reduction of about 2,000 in the number of locomotives. The adoption of continuous brakes is one of the most important single steps that can be taken by British Railways to improve the standard of their service, and it will be of material assistance in getting the best results from new forms of motive power. The estimated gross outlay on the provision of continuous brakes of the vacuum type is £75 million.

WAGONS

British Railways at present own over 1,100,000 freight wagons. Clearly there is a very substantial field for economies if the size of this wagon fleet can be reduced. One way is to increase their average size. There are, however, certain external factors to be taken into account. While, therefore, the Commission intend to develop full-load traffic by all means in their power, the scope for increasing the average size of merchandise wagons is limited.

More scope for the use of larger wagons exists in mineral traffic, where the Commission have recently introduced the largest coal wagon that can run on two axles on British Railways, with a capacity of 24½ tons. The problem of replacing the existing wagons of lower capacity by the new 24½-ton wagon is complex, involving the adaptation of terminal facilities and loading appliances, many of which are outside the Commission's ownership. The Commission have, however, decided that by 1974 half the coal-carrying capacity should be provided in 24½-ton wagons.

The second method of reducing the wagon stock is the reduction of round journey time, leading to an increase in the amount of revenue-earning work performed by each wagon. For the purpose of this plan the Commission have assumed an overall reduction of about 30 per cent. in wagon turn-round time. A more drastic reduction should be possible.

The wagon stock, on completion of the present authorised yearly programmes, up to and including the 1955 programme, will be divided as follows: open (merchandise), 309,700; covered (merchandise), 148,000; mineral, 606,900; special, 2,300; cattle, 12,600; steel-carrying, 47,100; brake vans, 14,900. The total is 1,141,500.

The important group of open and covered merchandise wagons totals 457,700. It is calculated that by 1974, owing to the expected improvement in turn-round time, this total will have fallen by between a quarter and a third, though the proportion of covered wagons in the total will have risen. In calculating the fleet of mineral wagons required by the end of the plan, the total tonnage capacity of the present fleet was assessed. After making provision for some increase in traffic, the ultimate number of wagons required was calculated taking into account, first, the planned replacement of old wagons and the progressive introduction of larger wagons, generally of 24½ tons' capacity; and secondly, the expected reduction in turn-round time. These calculations produced a mineral-wagon stock in 1974 as much as 40 per cent. below the present figure of 606,900.

The final stock of all classes of wagons forecast at 1974 will fall from 1,141,500 to approximately 752,000. The total number of wagons to be built to reach this position is 297,000, at a cost of £177 million. In the period 1956–70, 255,000 wagons will be built at a cost of £150 million, and this latter expenditure has been included in the plan.

PORTS AND OFFICE EQUIPMENT

Over and above the expenditure already listed, it will be necessary to provide improvements at the packet ports, in staff welfare, of office equipment and a sum for development and research.

In regard to shipping, the works required relate to the Continental services, the Irish services, and to various estuarial services. In addition to the work at the ports, other improvements will be required inland, such as at goods stations and at inland customs depots handling both freight and registered baggage. Such works can, of course, only be fully implemented if the responsible authorities on the Continent, in Ulster and Eire, follow suit, but their support is to be reasonably expected. No provision is required under the plan for new ships, since these would, in general, be built as renewals of existing vessels.

It is proposed to take full advantage of mechanical office equipment; in particular, the preparation of train schedules and paths is well suited to the use of electronic computing machines. Research and development work will be essential for the successful completion of the plan and at least £10 million will be allocated for this.

STAFF RECRUITMENT

The adoption of the plan will involve heavy demands on industry as a whole. In addition, there will be exacting demands made on the technical, traffic and operating, as well as administration staff of the Railways themselves. It is expected that industry will be able to increase its output capacity to meet the increased demands for its products. But to enable all these activities to be properly directed and to cope with the detailed planning, drawing and estimating, followed by the supervision and execution of the works that will have to be undertaken by the railways, there will clearly have to be a substantial increase in the Commission's technical staff.

Part of the difficulty of attracting young engineers to railway service in the past has been the fear on their part that no major development was ever likely to be undertaken, and that their prospects and experience in consequence would be limited: the plan should remedy this particular defect. A successful recruiting campaign will bring to the railways many men with basic technical knowledge but no railway experience, as well as those straight from school. The expansion of staff will require rapid promotion of young engineers to positions of responsibility. Training will therefore have to be undertaken both of recruits and junior staff to fit them to taking a full share of designing and controlling construction of works; training will also be required for potential senior engineers.

In addition to the drive for recruitment, outside assistance will be enlisted wherever possible. In particular, the service of consultants will be sought, though there are limits to their extensive use, since the work of the consultants must still be directed by senior railway engineering staff.

ECONOMICS

It is obviously difficult to forecast in detail the economic effects of the plan, the precise outcome being dependent upon the social and industrial situation of the country as a whole. It is to be noted, however, that almost half of the £1,200 million expenditure now proposed is required for the current replacement of assets falling due for renewal so that railway services may continue in their present state and form. But this reduced outlay would not be offset by improved results, nor would the trend towards obsolescence of the railways be arrested.

If the total proposed outlay of £1,200 million were spread uniformly over the next 15 years it would represent an annual investment of £80 million. This is no more than about 5 per cent. of the gross capital formation of the country in 1953, and a high proportion will be devoted to rolling stock rather than to building and civil-engineering works. Having regard to the rate of return that is expected, and to the fact that it will unlock much potential earning capacity latent in other assets, it is claimed that the expenditure proposed is attainable in practice and that the programme is realistic.

Of the £1,200 million, it is estimated that some £400 million will be available from internal sources such as depreciation provisions and so forth; the annual charge for interest and redemption on the external borrowings of the £800 million may be put at about £40 million. In addition to this financial charge, it will gradually become necessary to meet increased depreciation charges amounting to about £15 million arising from the need to base these provisions on the replacement costs of new assets instead of on the book values of those they replace.

The three requirements—interest on new capital, depreciation and rectification of low net earnings—together amount to £80 million. The actual return of the investment is expected to be of the order of £85 million and might be, it is thought, considerably larger. This return is made up of greater earnings and of reduced working costs of about £35 million on passenger services and of about £60 million on freight, but less £10 million or so for increased expenses of operation and superior management. To these countable returns, however, must be added the value of public goodwill that will follow from improved services, and the tonic effect on staff morale that should come with working with modern and efficient apparatus.

Conference on Problems of Aircraft Production (*concluded from page* 68)

FORGING, MACHINING, AND FORMING

In last week's issue we reported the introductory lecture on aircraft design trends, presented by Mr. Woodward-Nutt at the third annual conference on aircraft production held recently at Southampton University. We conclude the conference report with summaries of the three technical papers discussed. The principal points of the concluding paper, in which Mr. W. E. W. Petter raised the question "Where do we go from here?" were summarised in a Weekly Survey note in last week's issue.

FORGING PROBLEMS

The forging problems which arose when the aircraft industry, around 1948, began to demand intricate forgings with thin sections in high-strength aluminium alloys were described by Mr. G. W. Richards, (High Duty Alloys Limited), in a lecture on "Problems of Forging."

Initially perhaps the major problem was to produce a forged surface free from folds and surface flaws—not easily detected in the soft condition. Chromic-acid anodising of the heat-treated forging, preceded by polishing of the surface, was the most effective method of inspection yet devised. These and other methods were still being developed.

For thin-section forgings in high-strength aluminium alloys pressures of at least 20 tons per square inch were required at present. Existing equipment limited the possible size of component to approximately 600 square inch plan area. With increased thickness, lower specific pressures, and correspondingly larger plan areas, were possible.

In recent years there had been an unprecedented demand for forged slabs in high-strength aluminium alloys from which components could be machined for prototype aircraft. This often involves casting billets 1 to 2 tons in weight of forging quality; five years ago such billets were not available. Special procedures had been evolved for developing the full mechanical properties in the longitudinal, transverse and short transverse directions.

The chemical composition had to be closely controlled. Often it was only possible to obtain certain properties—e.g., full mechanical strength—at the expense of others—e.g., internal stress level. To develop the optimum tensile strength of extrusions or sheet, it was general practice to quench them after solution-treatment in cool or cold water. The high internal stresses thus induced were reduced by subsequent stretching, etc. This procedure could not be applied to a complex forging, without giving rise to severe distortion and sometimes failure during subsequent machining.

Small and medium-sized components of irregular shape should be quenched from solution heat-treatment at not less than 85 deg. C., and larger parts at 90 deg. to 95 deg. C. By such methods internal stress levels would be minimised and full specification mechanical properties could be maintained on test specimens cut from the component.

Not only solution heat-treatment temperature but also quench temperature had to be precisely controlled to a uniform level throughout the bath, and the loads arranged so that a temperature rise up to 10 deg. C. followed the quenching operation. The quench water should be changed frequently to avoid contamination, particularly if a salt bath had been used for solution heat treatment.

From the forging, it was obviously undesirable to machine complicated components from materials stock which required a cold-water quench to develop its mechanical properties. Preferably each part should be considered separately and a slab of appropriate size ordered to make the component. As soon as possible dies should be provided for the manufacture of such parts, thus permitting improved material utilisation, and the provision of a suitable grain flow within the component.

The lecturer then exhibited a series of slides illustrating the effect of quenching conditions (the results of temperature explorations on specimens in the quench bath) from which he demonstrated that the temperature of the quench water could influence cooling conditions much more than would be expected from the temperature difference. The internal stress level was reduced most effectively by quenching in boiling water. Anodising prior to heat treatment had drastic effects on the internal stress level.

MACHINING AND FORMING PROBLEMS

Experimental work on integrally-stiffened skins, proposed machine tools, and the machining of large and complicated fittings were described in the lecture by Mr. E. D. Keen and Mr. A. D. Menzies (Sir W. G. Armstrong Whitworth Aircraft, Limited) on "Machining and Forming Problems of Integral Construction."

After giving details of the machining, forming and heat-treatment processes used in experiments on integrally-constructed box spar flanges and test panels, carried out by the Armstrong-Whitworth company, Short Brothers and Harland, Limited, and the Bristol Aeroplane Company, Limited, the authors discussed the possibility of cast wings for high-speed aircraft which might be designed purely for stiffness. Casting would eliminate the removal of large quantities of metal and would facilitate the production of forms difficult to machine.

A contour-milling machine was vitally needed, and designers generally agreed that it could be based on the principle that the surface of a wing could be described by straight-line generators. Boulton Paul Aircraft, Limited, had proposed a machine in which the cutter was constrained to move successively along the straight-line generators of the component being formed. This machine could contour-machine wings of any planform, taper ratio, thickness/chord ratio and aerofoil section. The wing elements themselves could also be machined prior to assembly and, for internal machining of chordwise ribs, the cutter could be programmed in its spanwise transverse to give an intermittent vertical motion.

An improvisation for experimental work consisted in equipping a large plano-miller with a special milling head and a cutter tapered to correspond to the wing thickness taper, milling being performed chordwise. This would produce a step error in the surface contour necessitating hand finishing. The Armstrong Whitworth patent No. 12391/52 eliminated this, because the work was rotated about a virtual centre, the origin of the profile-generating lines. It also avoided the effects of flat facets which were one of the characteristics of the contour produced by the Boulton Paul machine.

The Armstrong Whitworth machine aimed to produce smooth wing surfaces from slab, with no hand finishing, by a wide milling cutter, reducing the number of sweeps to traverse a given area. The workpiece was held on to a block capable of moving in a horizontal plane on the machine bed. Screws at either end performing this motion could be driven at different rates dictated by the plan-form taper ratio. Spanwise above the workpiece was a beam carrying the cutting head, with a screw feed to progress the cutter at the end of each chordwise sweep, the angle and height of the beam being regulated by cams at the root and tip which moved with the work. By altering the milling head, the cutter could be made to move spanwise to form the integral stiffening inside the wing flange; heavy forged ribs could be machined to profile, and the blocks to which the workpiece was clamped could also be machined on it.

The authors then discussed the use of steel forgings, for spars and spar fittings. For their machining, higher-powered tools with lower speeds and feed rates were required. Many of the operations required machines fitted with tracer control mechanism. In a typical pair of spar root-end fittings in a 75-ton nickel chromium steel (S. 98), 34 operations were required and the weight of the finished part was 50 lb. compared with the original forging, 150 lb. Slight differences in hardness in different batches of forgings had noticeable effects on the machining time. All finishing operations had to be preceded by a roughing-out to relieve internal stresses.

The main general conclusion that emerged from the discussion following the papers on forging and machining problems appeared to be that, while the acquisition of a 50,000-ton press and suitable machine tools was highly desirable, it was far more urgent to acquire stretcher presses, since stretching after solution treatment afforded the only satisfactory method of removing distortion. American difficulties in forging intricate thin-webbed complex components, it was suggested, indicated that machining from slab was likely to be more productive and emphasis, therefore, should be directed to the development of large slab materials with improved transverse-grain elongation properties.

The use of shot-peening for forming to contour panels machined in the flat, a much simpler process than contour-milling, as an alternative to stretch-forming was suggested. As regards tools for machining light-alloy forgings, much could be done by developing and adapting existing tools, in particular, wood-working tools; but new machine tools would be necessary when the change-over to steel construction was made.

HIGH-SPEED MACHINE TOOLS

Comparatively simple and inexpensive machine tools constructed recently and still under development, which can help to reduce the cost of machining light alloys, were described in a paper entitled "High-Speed Machine Tools for Aircraft Production," presented by Mr. S. Radcliffe (Wadkin, Limited). An abridged version of this paper will be found elsewhere in this issue.

In brief, Mr. Radcliffe described progress in routing techniques—in the type of machines becoming available, improved cutters and increased horse-power. He gave details of a new universal milling machine under construction and a new spar milling machine specially designed for the British aircraft industry, the latter machine designed for handling steel as well as light alloys. Shortly to be constructed was a large sawing machine for handling billets 45 ft. long by 10 ft. wide, up to 5 in. thick; and finally Mr. Radcliffe described a possible design for a band-sawing machine for cutting expanded honeycomb alloy to profile.

In conclusion, he posed the question, was there a need for a range of simple machines, or was the ideal "press-the-button" on an expensive and complicated machine? With the advent of electronic control, substantial advantages—elimination of solid formers and the resultant speed-up between the design and production stages—were obtained from the additional complication.

In the discussion following Mr. Radcliffe's paper, the question of swarf accumulation from the high-speed cutters was raised. Mr. Radcliffe thought that it should be possible to rearrange the cutters to throw the swarf clear of the machine; exhaust hoods would be necessary for swarf removal. In reply to a query on equipment for cutting steels, Mr. Radcliffe replied, on behalf of the machine-tool industry, that suitable machinery under development would be seen at the 1956 Machine Tool Exhibition.

Another viewpoint on integral construction was presented in a lecture entitled "The Manufacture of Integral Structures," given to the Royal Aeronautical Society on January 18 *by Dr. E. G. West, technical director of the Aluminium Development Association. An abstract of this paper will be given in next week's issue.*

BOOK REVIEWS

Mechanical Failures of Metals in Service. By J. A. BENNETT and G. W. QUICK. U.S. National Bureau of Standards Circular 550. *The Superintendent of Documents, U.S. Government Printing Office, Washington 25, D.C., U.S.A.* (30 cents.)

For many years the National Bureau of Standards has undertaken, at the request of other American Government agencies, investigations of service failures in metal components of ships, aircraft and road-transport vehicles. In the belief that the results of such work have a wider interest than solely to the agencies primarily concerned, and should prove instructive to industrial metallurgists and engineers, a representative selection of the examinations made from 1940 to 1951 has been summarised and is presented in this Circular along with some general remarks on the predominant causes of mechanical failures and the precautions necessary to avoid them

The 35 examples in the collection fall into three main groups, characterised respectively by single overload, fatigue, and stress combined with corrosion as the immediate cause of failure. Almost without exception, however, the associated secondary causes determine why any particular component, out of many nominally identical ones subject to similar working conditions, actually fails. To such factors, of which defective material, porosity in castings, incorrect heat treatment and stress concentrating features of shape or surface finish are typical, adequate recognition and critical discussion are accorded. Failures due to wear or imperfect lubrication are not covered, and only one instance of failure by excessive deformation is included.

Not unexpectedly, an important proportion of the reported failures occurred in aircraft, one case of topical interest being the development of cracks in a structural member of aluminium alloy. They were attributed to high internal stress combined with mild corrosion due to marine atmosphere, and it is noteworthy that in some cases their progress was arrested by drilling small holes at the ends of the cracks. The abundant photographic reproductions illustrating the text are well chosen and remarkably clear except in one or two cases where fine detail cannot be as fully appreciated as by visual inspection of the actual component. The reports do not mention anything very novel in the way of examination techniques, and only a few of the failures themselves lie outside the scope of many "trouble shooting" mechanical laboratories. The greatest potential value of the Circular is to those responsible for the design, fabrication, use and maintenance inspection of machines and structures, all of whom must concede, after studying it, that service failures are far more common than is inevitable in the present state of mechanical and metallurgical science.

Glass Reinforced Plastics. Edited by PHILLIP MORGAN. Published for "British Plastics" by *Iliffe and Sons, Limited, Dorset House, Stamford-street, London, S.E.*1. (35*s.*)

In the production of almost all types of plastics a resin binder and a filler must be combined. It was recognised before the war that glass fibre would be an excellent filler because of its tensile strength, electrical insulation properties, and several other advantages, but it was found that the high pressures needed to mould plastics using phenolic resins damaged the glass fibre. During the war polyester resins were produced, which could be moulded at low pressure, and their combination with glass fibre began the development of glass reinforced plastics. That development has proceeded rapidly, and Phillip Morgan's book gives a timely summary of the work already done and new techniques and applications for the future.

The book is made up of fifteen papers written by experts in the field of glass reinforced plastics. The papers fall into three main groups, one on materials, another on moulding techniques, and the third on applications. The book has been carefully edited, and there is little overlapping between the chapters. The chapters on materials deal with the glass fibre and the predominantly used polyester resins, but include accounts of the use of phenolic, silicone, epoxide and other resins as binders for glass fibre. Techniques of moulding are constantly being improved, and the methods of mass production by preform machines are most ingenious. Tube and rod manufacture is a new use for glass reinforced plastics, and this intricate process is lucidly described. Applications for these plastics fall under four main headings: aircraft, car bodies, boat building, and miscellaneous uses. There is a very interesting chapter by Lorne Welch on the general principles of design using plastics, the properties of which differ so much from those of conventional materials.

All the papers are written for engineers and designers who have no special knowledge of plastics production, although the chapters on the chemicals used for the plastics could only be completely understood by chemists or chemical engineers. There is a comprehensive table of references at the end of each chapter, and the reader is greatly helped by many illustrations, tables, and diagrams. The only notable omission is a glossary of terms used in the plastics industry some of which are likely to baffle the average engineer.

The book is a most useful account of the present state of the glass reinforced plastics industry. It could be read with advantage by most engineers because the use of these materials may extend in the near future to almost every branch of engineering.

A History of the School of Engineering, Columbia University. By JAMES KIP FINCH, Dean Emeritus of the Faculty of Engineering. *Columbia University Press, Morningside Heights New York* 27, *N.Y., U.S.A.* (2·75 dols.); and *Oxford University Press* (*Geoffrey Cumberlege*), *Amen House, Warwick-square, London, E.C.*4. (22*s.*)

The contrast between the history of the development of American and European universities is well brought out in this book, one of 19 volumes in the Bicentennial History of Columbia University. Most American Universities owe their foundation as schools of agriculture and mechanic arts to the grants of land made by the Federal Government under the Morrill Act of 1862, and developed their pure science and "liberal arts" faculties afterwards.

Columbia was granted a charter as King's College by George II in 1754 and started in the English tradition of the classics and humanities. Nevertheless it soon had chairs in Natural Philosophy, and Arts degree students read engineering and science subjects until the foundation of the School of Mining and Metallurgy in 1864. This school quickly became of larger size than the old college and from it grew first the various departments of Engineering and, in 1892, the faculty of Pure Science. In this way Columbia followed the practice of the land grant colleges, and the history of science itself, whereby the practical arts mothered the study of basic principles. To-day, there are seven separate departments in the Engineering School: Civil: Mechanical; Electrical; Mining, Metallurgical and Mineralogical Engineering; Chemical; Industrial and the Service Department of "Graphics" for the teaching of drawing and industrial design to both engineering and architectural students.

It was under the 40-year presidency of the famous and controversial Nicholas Murray Butler that Columbia pioneered the broader education of engineering, that, in recent years, has become increasingly popular. As early as 1895, seven years before he became president, he had attacked the development of technical schools, with low standards of entrance, attached to universities, and pointed out the danger of allowing purely technical or professional work, entered upon without any broad preparatory training, to be regarded as legitimate university work. These views, and the subsequent developments at Columbia and elsewhere in the United States, must be considered in relation to the lower level of school education of undergraduates in that country and the fact that the Bachelor's degree is, in general, of a lower level than that awarded here. The British honours degree is roughly equivalent to the American Master.

In 1914 a six-year course was introduced, in which the student had first to qualify for the A.B. degree at the College before becoming eligible for the professional engineering course. Whether as a result of the severity of this course or the onset of the war, this change caused a very severe drop in registrations and, in 1922, a return was made to a four-year course in which the student was required to take liberal arts subjects during the first two years. This led to the Bachelor of Science degree. In addition, a five-year course was instituted by which the student received A.B. from the College and B.S. from the Engineering School. A further one year of graduate study led either to the professional degrees of Civil, Electrical or Mechanical Engineer, or to a Master of Science.

This is the pattern of present-day engineering education at Columbia. It can obviously leave little time for specialisation up to the Master degree level, but during the last fifty years Columbia has become more and more a graduate university and an increasing amount of specialised research work is being done by students working for Doctorates. Particularly since the war has the amount of research work grown; with the result that the already overcrowded buildings on Morningside Heights became quite inadequate. In 1948 a site was acquired on which is being built a new engineering centre for laboratory instruction and research.

This interesting book would have been made even more so, if its author had been able to include some comparative biographies of those trained at Columbia and at more traditional schools by which some assessment of the Columbia method could have been made.

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BOOKS RECEIVED

Some of the books noticed in the Books Received column are selected for extended review in later issues of ENGINEERING.

Heating in Industry. By G. A. WILLIAMS. *The Association of Engineering and Shipbuilding Draughtsmen, Onslow Hall, Little Green, Richmond, Surrey.* (3*s.*)

Information for designers, draughtsmen and others concerned with the installation of heating systems in buildings. High and low-pressure steam and hot-water systems are described with full data for making calculations. Thermostatic and automatic controls are discussed and illustrated. A section is devoted to gas and electric heating and there is a summary giving the advantages of the different types. There are 15 tables at the end which give data relating to heating problems.

The German Plastics Industry during the Period 1939–1945. By N. J. L. MEGSON and H. J. E. POUPARD. British Intelligence Objectives Sub-Committee Surveys Report No. 34. Published for B.I.O.S. by *H.M. Stationery Office, Kingsway, London, W.C.*2. (6*s.*).

This report presents information gathered by visiting teams of investigators immediately after the end of the war. It deals with polymeric products used for plastics, and with ancillary materials, fabrication techniques and the main applications of plastics. Sections dealing with plant, equipment, and testing methods are included. Paints have been covered only where they use special resins, and textile applications are included up to the stage of polymer production for spinning. References to elastomers are limited to certain special cases. The appendix includes a list of trade names in the German plastics industry.

Mechanical World Year Book, 1955. *Emmott and Company, Limited,* 50 *Temple Chambers, Temple-avenue, London, E.C.*4. (3*s.* 6*d.*).

In the 68th edition of this book, the sections on materials have been brought together in one group

of pages for easier reference. Thus ferrous, non-ferrous and plastic materials, and the related subjects of heat treatment, die-casting and hardness testing now appear on consecutive pages. Particular attention has been given to the data on steels and non-ferrous alloys, and to materials for special purposes such as gas turbines.

Mechanical World Electrical Year Book, 1955. *Emmott and Company, Limited, 50 Temple Chambers, Temple-avenue, London, E.C.4.* (3s.)

For this edition the section on control gear has been entirely rewritten and brought up to date. Notes have been added on the care of electric motors, and on electric brazing and soldering, and an entirely new section deals with the suppression of interference with radio reception.

Automatic Protection of A.C. Circuits. By G. W. STUBBINGS. Fourth edition revised and edited by C. M. DOBSON. *Chapman and Hall, Limited, 37 Essex-street, London, W.C.2.* (50s.)

The fourth edition has been completely revised, and the chapters dealing with relays and protective systems and the glossary of protective gear engineering terms have been re-edited. An additional chapter dealing with the earthing of power system neutrals has been included, and information regarding the selection and performance of protective gear normally provided on modern electrical equipment has been added.

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TRADE PUBLICATIONS

Copies of any of the following trade publications are obtainable from the addresses given, though distribution is sometimes restricted.

Choosing Electric Motors. BRITISH THOMSON-HOUSTON CO. LTD., Rugby. The considerations involved in choosing an electric motor. Questions of "duty," "characteristics" and "service conditions" are discussed in detail and methods of calculating capacity, starting time and heating are given, with examples. There is also a section on motor design. 40-page booklet written by C. V. Hill, B.Eng. entitled "The Choice of Electric Motors."

Contractors' Plant. BLAW KNOX, LTD., 94 Brompton-road, London, S.W.3. Concrete mixers: two leaflets describing the latest versions of two-wheeled and four-wheeled 5/3½-ton Rex mixers. Motor Graders: leaflet describing the BK-12 heavy-duty motor grader, and supplementary leaflet giving details of the elevating-loader attachment for the "Super 12" and "12" graders.

Standard Steel Buildings. SANDERS AND FORSTER, LTD., Thames Works, Hertford-road, Barking, Essex. Standard steel-framed building, including all cladding, windows, doors, etc., supplied out of stock and erected on clients' foundations. One, two or three spans of 45 ft., length unlimited; crane gantries available. Typical drawings and descriptive leaflets.

Douglas Fir Plywood. HIGH COMMISSIONER FOR CANADA, Canada House, London, S.W.1. Three booklets giving notes on qualities and uses of Canadian Douglas Fir plywood, for which import and consumption restrictions in the U.K. were removed last year. In particular, one booklet deals with concrete formwork, giving tables of permitted loads, stresses, etc.

Bailey Bridging. THOS. STOREY (ENGINEERS) LTD., Stockport, and 6 Victoria-street, Westminster, London, S.W.1. Company are sole world licensees for manufacture and sale of Bailey bridging equipment. Booklet *The Storey Survey, 1954* describes bridging work undertaken in U.K. and overseas. Also notes other activities of company: mechanical handling and agricultural machinery.

Flameproof Switchgear. THE BELMOS CO. LTD., Bellshill, Lanarkshire. Air-break automatic reversing, auto-transformer, and star/delta contactor starters, Buxton certified for Groups I, II and III gases; non-flameprocf contactor unit for capacitor switching, 650 volt, 20 amp. type AJ.150. Four illustrated leaflets.

Stock Control and Invoicing System. POWERS-SAMAS ACCOUNTING MACHINES (SALES) LTD., 88 High Holborn, London, W.C.1. Description of a punched-card system for the stock control and invoicing of small tools; details are given of procedure and checks against error. Article in the Company's magazine, vol. 20, No. 9.

Glue Pen. GLUE PEN CO., 143 Cannon-street, London, E.C.4. "Fastik" glue pen dispensing fast-drying paper-sticking glue in dots. Illustrated leaflet.

ECONOMIES OF INTEGRATION

FUEL SAVED BY PRODUCING STEEL IN A SINGLE WORKS

In a paper presented to the Institute of Fuel on January 13, with the title of "A Study of the Effect of Integration of All Departments on the Fuel Economy of an Iron and Steel Works," Dr. W. F. Cartwright and Mr. J. T. Davies, both of the Steel Company of Wales, described how fuel economies could be achieved when all the processes of production were carried out in a single plant as compared with five separate plants separated some distance apart. The five plants that they considered were: a coal-washing and coking plant, probably at the pithead; a merchant blast-furnace producing cold pig iron; a steel plant using cold pig iron and scrap, and sending ingots to an adjacent slabbing mill; a hot strip mill receiving cold slabs from the slabbing mill; and a pair of works, one producing tinplate and the other cold reduced sheets, both from strip delivered from the hot-strip mill.

The authors studied two questions: first, what is the thermal consumption of the integrated works as compared to that of the non-integrated works; and second, what are the relative costs of fuel. They assumed that neither blast-furnace gas nor waste-heat steam could be used except close to, or at the plant in which they were produced, but that other fuels were transportable with a probable increase in cost. As regards production, the figures on which the estimates are based were:

Coke production ..	23,000 tons per week
Pig-iron production	29,000 „ „
Steel production ..	44,000 ingot tons per week
Hot-strip mill production	37,500 tons per week.

Of the strip-mill production, 16,500 tons were taken as being allocated to the tinplate cold reduction mill and 10,500 tons to the cold reduction sheet mill, the remainder being allocated to hot finished sheets and plates. These figures were assumed to be the outputs of both the integrated and the non-integrated works. The authors then gave details of the use of fuels in the processes.

INTEGRATED WORKS

Coke Ovens.—The whole output would be sent to the blast-furnace department with the exception of a small quantity of breeze used for soaking-pit bottoming work and perhaps a few beans for outside sale. Steam would be supplied from the blast-furnace plant or the steel plant and the ovens would be heated by blast-furnace gas.

Blast Furnaces.—All the nuts and the coke would be used directly in the blast furnaces. The gas produced would be used for ignition in the sinter plant, for heating the blast-furnace stoves, for heating the coke ovens, for heating the lime kilns and as the main fuel on the soaking pits. The large surplus would be used for raising high-pressure steam.

Alternative Fuels.—The steel plant could use coke-oven gas made up with fuel oil and tar, or fuel oil and tar only. The slabbing mill would derive most of its heat for the soaking pit from the hot ingots, the main use of fuel being to supply power for the mill itself.

Hot Strip Mill.—Coke-oven gas, natural gas, or fuel oil would be needed to heat the slabs. Power requirements to drive the mill are very large.

Cold Reduction Sheet and Tinplate Plants.—Low-pressure steam for the pickling plant; power for the reduction mill and heat for the annealing furnaces. Waste-heat steam would be used and coke-oven gas.

NON-INTEGRATED WORKS

Coke Ovens and Coal Washing.—Steam from coal-fired boilers; coke-oven gas for the ovens.

Blast Furnaces.—Fuel would be wasted as the pigs would be cold, there would be surplus blast-furnace gas which could be sold to a power station or used to generate power directly at a very small profit.

Alternative Fuels.—Fuel oil and tar would be required for the steel plant, probably bought from the coke-oven plant. Heat would be needed for the cold pig iron. Waste-heat steam for the slabbing mill and fuel for the soaking pits.

Hot Strip Mill.—Coke oven gas or fuel oil for slab heating, and power for driving the mill.

Cold Reduction Sheet and Tinplate Plants.—Coal-fired boilers to raise steam for the pickling plants, gas oil for the annealing furnaces and tinpots.

COMPARISONS

The authors gave at the end of the paper, 16 tables showing the costs of each section and the heat balance sheets for each plant. The table giving the final comparison between the two complete plants is below. From a purely thermal point of view, the authors showed that the integrated works only had a saving of 6·6 per cent. However, owing to the extensive possible use of low-grade fuels in the integrated works, the monetary advantage amounted to approximately 24·6 per cent.

	Integrated Works						Non-Integrated Works					
	Purchases		Sales		Balance		Purchases		Sales		Balance	
	million therms	£	million therms	£	million therms	£	million therms	£	million therms	£	million therms	£
Coke-oven plant	10,300	133,800	9,012	193,200	1,288 debit	59,400 credit	9,577	126,400	8,190	182,500	1,387 debit	56,100 credit
Blast-furnace plant* (sinter plant and lime kilns)	7,586	157,200	2,345	24,400	5,241 debit	132,800 debit	7,173	158,200	1,871	2,700	5,302 debit	155,500 debit
Steel plant and slabbing mill	2,843	59,000	207	2,200	2,636 debit	56,800 debit	3,040	70,800	nil	nil	3,040 debit	70,800 debit
Hot strip mill	1,231	28,400	13	100	1,218 debit	28,300 debit	1,299	29,500	nil	nil	1,299 debit	29,500 debit
Cold sheet plant	496	9,400	nil	nil	496 debit	9,400 debit	463	10,300	nil	nil	463 debit	10,300 debit
Tinplate plant	911	19,400	nil	nil	911 debit	19,400 debit	1,047	22,000	nil	nil	1,047 debit	22,000 debit
Power plant (water services)	1,307 81	13,100 1,900	1,157 nil	14,300 nil	230 debit	700 debit	1,871 Purchased from blast furnaces	39,800	1,591 Sold to above plants	37,400	280 debit	2,400 debit
Grand total	24,755	422,200	12,734	234,200	12,020 debit	188,000 debit	24,470	457,000	11,652	222,600	12,818 debit	234,400 debit

* It is assumed that the blast-furnace plant generates electricity at a cost of 0·7*d.* per unit (kWh); also that the buyers of exported electricity pay 0·75*d.* per unit. Therefore, credit to blast-furnace plant for exported electricity = 0·05*d.* per unit.

The Engineering Outlook—3

AGRICULTURAL MACHINERY

INCREASED DEMAND IN EXPORT MARKET

At the beginning of 1954 the agricultural machinery industry had experienced two years of declining sales and prospects in the home market were clouded by doubts regarding the effect of changes in agricultural policy on home purchases of farm equipment. Nevertheless, there were already signs of increasing demand and most manufacturers, particularly in the tractor field, were looking forward to increased production in 1954 as compared with the previous year. In general these hopes have been fully realised though the increase in output has been by no means evenly spread over the industry and production of certain classes of machinery has continued to fall.

In the year ending September 30, 1954, the total production of agricultural machinery amounted to £106·1 million compared with £94·0 million in the previous year and the record total of £111·1 million in 1951-52, as shown in Fig. 1. Although production in any one year is fairly evenly divided between home and export markets it is interesting to note that the fluctuations in output have been caused mainly by variation in export demand and production for the home market in the last four years has not varied by more than 10 per cent. In view of the uncertainty among farmers early in 1954 due to the abandonment of the system of fixed prices for most agricultural products, and the declared intention of the Government to introduce more competitive conditions with the object of eventually securing a substantial reduction in the food subsidies, it is encouraging to see that production of agricultural machinery for the home market reached £49·9 million in the year ending September 30, 1954, the highest figure recorded for the last four years.

Since the 1953 February price review was expected to result in a fall in farm income in 1954-55 of £23 million and in a full year of £30 million some surprise has been expressed at the ability of farmers to finance further mechanisation on this scale. It must not be overlooked, however, that the 1953 harvest was a good one and the amount which a farmer can afford to spend on new machinery in any one year is very largely determined by his harvest surplus in the previous year. It would seem that during 1954 many farmers realised that if they were to succeed under the more competitive conditions likely to be experienced in the future they must increase their efficiency through greater mechanisation. Another factor was undoubtedly the new investment allowances applicable to new agricultural building and works and to new plant introduced in the 1954 Finance Act as an earnest of the Government's intention to help farmers reduce unit costs of production. In so far as they affected farmers these were explained by the Minister of Agriculture in a statement in April. He explained that the new allowance of 20 per cent. of the cost of plant and machinery was more favourable than the existing initial allowance basis because it was additional to normal depreciation instead of being an initial allowance in anticipation of such depreciation. As an example he stated that in the case of a tractor for which the ordinary depreciation rate was just over 28 per cent. there would be no change in the first year since relief could still be claimed on just over 48 per cent.; in the subsequent life of the tractor, however, relief could be claimed on just under 72 per cent. instead of just under 52 per cent. as was the case before.

Turning to consider particular classes of agricultural machinery it was in tractor production that the biggest increase occurred in the past year, the output of agricultural tractors of all types in the year ending September 30 being 133,000 compared with 109,200 in the previous year. The 1953-54 figure was higher than that for 1951-52 but did not quite reach the peak of 139,500 for 1950-51. There was also some recovery in the output of market garden tractors though production at 30,300 for the year ending September 30, 1954, failed to reach the 1951-52 total of 34,000.

Reference to the figures in Fig. 2 relating to total production and production for export of agricultural and industrial wheeled tractors show that fluctuations in output over the last four years have followed variations in export demand very closely, but in 1953-54 there was an expansion in both home and export demand. In the case of tractor drawn mouldboard ploughs, disc harrows and potato spinners shown in Fig. 3, and corn drills in Fig. 5, there was only a very slight rise in output in the past year and the figures are still well below those of the peak years 1951 and 1952. To some extent this has been due to a failure of exports to recover to any great extent from the relatively low levels of 1953 but it also reflects the fact that the life of these items of equipment is relatively long (they are less likely than tractors to be outdated by changes in design and tend to be used until they finally wear out) and the heavy purchases in the years up to 1952 appear to have largely saturated the market for the time being. In export markets local competition in the case of implements is very much more severe than for tractors. There was a good recovery in 1954 in the production of both mowers and combine harvesters, as shown in Fig. 5. Production of milking machines has also recovered, as shown in Fig. 4.

The biggest increase in output of agricultural machinery generally took place in the third quarter of 1954, when the production of tractors both for the home and export markets was running at about 30 per cent. above the corresponding figure for 1953. In the fourth quarter there was the usual seasonal decline in output which, nevertheless, continued well above the level of the previous year. In the case of implements and machinery, other than tractors, production in the third quarter of 1954 was only about 10 per cent. above that for the corresponding period in 1953, and the variations in activity in the different sections of the industry have naturally affected manufacturers in different ways.

The Massey-Harris-Ferguson group reported in November that their output of tractors had been running for several months at about 340 tractors a day and although it had since been reduced to 250 a day owing to the seasonal decline in home demand, they expected to

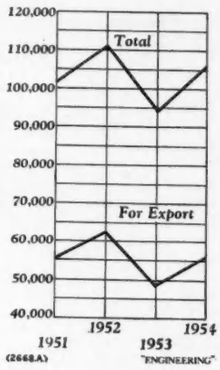


Fig. 1 Production of agricultural machinery in £ million for year ending September 30. The upper values are total production, and the lower export only.

produce 63,000 tractors in 1954 compared with 56,000 in 1953 and 74,000 in 1951. The group, however, were particularly successful in expanding sales of implements and the Massey-Harris Company alone increased its sales of implements other than tractors and combine harvesters by 50 per cent. in the first nine months of 1954. The Ford Motor Company, on the other hand, reported a considerably greater expansion in sales of tractors than of implements and was expecting that exports of Ford tractors for the full year would be about 50 per cent. greater than for the previous year. This reflects in large measure the success of the new design introduced by the company in the previous year, which proved very popular in Australia and enabled the company to re-enter the Brazilian market. The David Brown Corporation estimated in November that home sales of tractors for the year would be about 3,050 and exports about 7,800, while the sale of implements in export markets was expected to reach about 3,000 compared with 2,000 in the home market.

INCREASING SALES TO THE U.S.A.

A striking feature of Table I, which shows exports of agricultural tractors by country of destination, is the marked rise in exports to the U.S.A. from 3,943 valued at £800,000 in 1953 to 8,321 valued at £3·2 million in the first 11 months of 1954. This brings out the strong competitive position of British tractor manufacturers in export markets; the Ford Motor Company, for example, claim that they can market a Diesel tractor in the U.S.A. more cheaply than American manufacturers can market an equivalent petrol model. In 1954 the U.S.A. had become the second largest export market for British tractors; exports to Sweden, which formerly held this position, had shown a marked fall compared with 1953. Australia, to which exports rose from 14,845 in 1953 to 16,761 in the first eleven months of 1954 continued to be the most important export market and other countries which took sub-

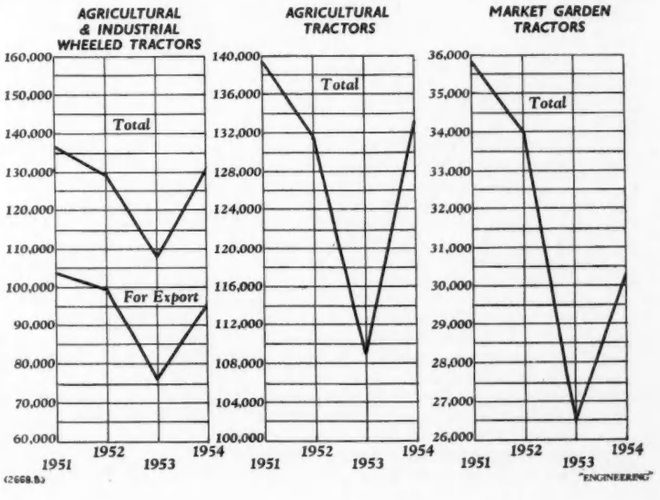


Fig. 2 Agricultural and horticultural tractors made in the United Kingdom during the last four years.

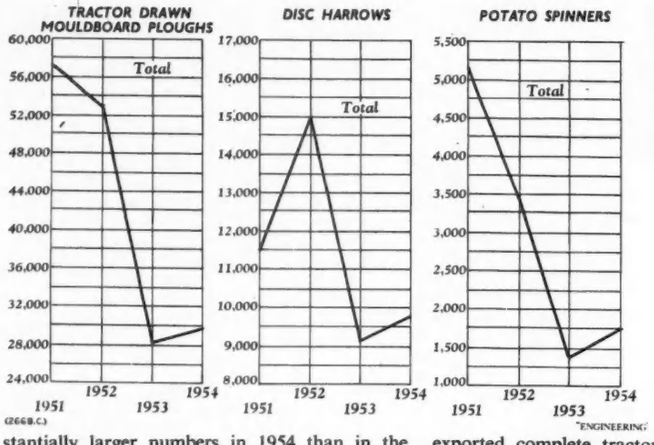


Fig. 3 Mouldboard ploughs, disc harrows and potato spinners made in the United Kingdom since 1951.

stantially larger numbers in 1954 than in the previous year include South Africa, India, New Zealand, the Irish Republic, Spain, Turkey, Brazil and Uruguay.

PROSPECTS IN OTHER EXPORT MARKETS

During the year a substantial order was received from Iran, the first to be obtained from that country since 1950. The order covered 1,000 tractors to be supplied by the Ferguson Company, combine harvesters from the Massey-Harris Company and implements to be supplied by Ransomes, Sims and Jeffries Limited, the total value being £1·6 million. Ethiopia is another country which may become an important market for agricultural machinery. Representatives of the Massey-Harris-Ferguson organisation who visited the country towards the end of 1953, made arrangements for the distribution of Ferguson tractors in that country and the first shipment of tractors and implements arrived early in 1954.

Egypt, though still a relatively small export market, has been steadily increasing her imports of tractors and in the long run is expected to develop still further since the Egyptian Government is embarking on several reclamation projects. Sales of tractors have, however, been adversely affected by the Land Reform Law of September, 1952, which provided for the breaking up of large estates into small peasant holdings. The law provides for the setting up of co-operative societies which will jointly own farm machinery but it is expected to be some time before these are organised and can take the place of the large landowners who were formerly the principal buyers of agricultural machinery.

It was pointed out in this series last year that hitherto Latin-American markets have not been among the most promising for British agricultural machinery manufacturers largely owing to the commanding position held by U.S. manufacturers assisted by loans from the U.S. Government under the Point Four Programme. In 1954 there was some recovery in British exports of tractors to both Brazil and Uruguay, the only two South American countries to which exports are shown separately in the Trade and Navigation Accounts, though in both cases the 1954 total remained well below that for 1952. In the case of agricultural mahinery other than tractors there was a further marked fall in exports in 1954 and there would seem to be a serious risk of losing this market altogether. In nearly all the South American countries there is a very large potential demand for agricultural machinery, but apart from the ascendancy of U.S. manufacturers and currency difficulties many of the South American Governments are insisting that production, or at least assembly, shall be carried out in their own country. In the Argentine for example it was announced in February, 1954, that the Government were anxious to start the manufacture of tractors as soon as possible. In the meantime arrangements had been made to import partly complete tractors from the David Brown Corporation, which had formerly exported complete tractors to this market, so that a start could be made by manufacturing certain parts there. It was stated that the country's total immediate requirements amounted to 100,000 tractors and once these were supplied there would be a continuing demand for about 20,000 a year. Competition in supplying these requirements is to be expected not only from U.S. but also from German manufacturers who are already manufacturing diesel engines in the Argentine. In deciding to establish an assembly plant in the country the David Brown Corporation took advantage of the Argentine's new foreign investment law which provides a guaranteed right to take profits out of the country. In developing the project the company will be able to draw on its experience in India to which the first consignment of "knocked down" David Brown tractors was sent at the end of 1953. These were assembled by the David Brown Concessionaires in Bombay who hoped to manufacture or supply from Indian sources an increasing number of components. Towards the end of 1954 it was announced that the Argentine Government had concluded agreements with four European tractor manufacturers (Fiat, Fahr, Deutz and Hannomag) for the construction of four tractor factories with a combined minimum output of 12,800 units per annum. The total capital investment was said to be about £25 million.

In Brazil also it is reported that a plant is to be established to produce 2,000 tractors per annum. It has been stated that the plant is to be erected in the neighbourhood of Taubate in the province of Sao Paulo but no further steps have been taken beyond the selection of the locality.

During 1954 Peru received a loan of 1·7 million dols. from the International Bank for Reconstruction and Development for the purchase of agricultural machinery needed to open new areas of cultivation and improve methods of production, the loan to be repaid over five years in half-yearly instalments starting on July 15, 1956. It is estimated that during the five years, the

TABLE I.—UNITED KINGDOM: EXPORTS OF AGRICULTURAL TRACTORS, BY COUNTRY OF DESTINATION

	Quantity (Numbers)			Value (£1,000)		
	1952	1953	1954 Jan.-Nov.	1952	1953	1954 Jan.-Nov.
South Africa	4,008	5,948	7,559	1,539	2,447	3,299
Southern Rhodesia	569	514	707	276	242	307
Kenya	674	393	491	361	193	286
India	953	968	1,656	468	376	644
Australia	13,999	14,845	16,761	4,902	5,260	6,255
New Zealand	6,827	7,646	8,070	2,559	3,096	3,193
Canada	6,541	3,889	4,051	2,429	1,803	1,567
Other Commonwealth Countries	3,382	2,746	2,607	1,667	2,043	1,563
Irish Republic	3,070	3,737	4,460	1,180	1,571	2,035
Finland	5,407	1,835	2,715	2,167	812	1,301
Sweden	10,860	11,202	6,838	4,433	4,433	2,839
Norway	4,044	3,584	4,215	1,351	1,354	1,709
Denmark	11,125	8,412	7,693	4,089	3,181	2,826
Netherlands	2,517	1,929	2,663	966	816	1,078
Belgium	2,015	1,793	1,482	844	725	587
France	4,824	6,140	4,082	2,085	2,431	1,535
Spain	1,023	1,250	1,626	650	822	864
Italy	3,858	4,636	4,203	1,806	2,313	2,034
Yugoslavia	1,129	111	20	559	118	45
Greece	399	206	174	204	100	93
Turkey	8,301	813	1,274	4,843	683	799
Algeria*	1,049	1,396	893	562	786	567
Egypt	210	385	411	74	140	180
U.S.A.	2,151	3,943	8,321	277	800	3,229
Cuba	389	370	195	169	179	101
Brazil	1,420	532	634	622	247	313
Uruguay	1,331	389	828	619	227	483
Other Foreign Countries	4,973	5,881	6,863	2,486	3,289	4,136
Total	107,048	95,493	101,492	44,187	40,487	43,868

* Including French Morocco

TABLE II.—UNITED KINGDOM: EXPORTS OF AGRICULTURAL MACHINERY OTHER THAN TRACTORS, BY COUNTRY OF DESTINATION

	Quantity (Numbers)			Value (£1,000)		
	1952	1953	1954 Jan.-Nov.	1952	1953	1954 Jan.-Nov.
South Africa	89,660	64,081	57,374	1,075	862	784
Southern Rhodesia	19,216	16,330	15,768	224	211	215
Kenya	26,496	21,535	16,444	420	293	287
India	39,844	10,719	12,547	495	151	168
Ceylon	9,689	7,308	2,422	197	112	52
Australia	207,453	139,486	163,271	3,251	2,438	2,754
New Zealand	106,405	74,037	64,114	1,685	1,168	1,083
Canada	52,827	53,283	48,092	524	498	456
Other Commonwealth Countries	74,805	63,762	50,313	1,153	999	909
Irish Republic	110,827	127,740	161,930	1,216	1,410	1,871
Finland	63,548	7,067	22,244	1,069	155	468
Sweden	34,025	18,504	22,450	536	332	410
Norway	17,607	8,664	11,166	323	175	223
Denmark	40,644	21,466	27,403	521	336	442
Netherlands	32,831	25,872	26,725	335	324	344
Belgium	25,889	18,296	14,605	326	247	200
France	80,899	71,486	29,660	1,371	1,315	479
Algeria*	11,035	21,636	16,446	183	303	267
U.S.A.	51,207	52,567	42,069	607	639	454
Brazil	18,669	8,722	2,826	454	74	27
Turkey	203,955	40,804	2,826	2,710	819	33
Other Foreign Countries	190,597	159,287	188,709	2,584	2,296	2,982
Total	1,508,128	1,032,652	997,258	21,259	15,157	14,908

* Including French Morocco

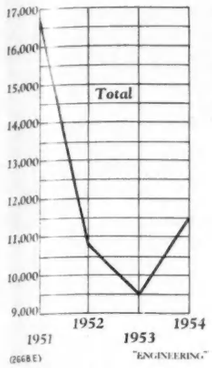


Fig. 4 Number of milking machines made in the United Kingdom since 1951.

TABLE III.—UNITED KINGDOM: EXPORTS OF AGRICULTURAL MACHINERY

—	Quantity (Numbers)			Value (£1,000)		
	1952	1953	1954 Jan.-Nov.	1952	1953	1954 Jan.-Nov.
Types other than tractors:						
For preparing and cultivating the soil:—						
Ploughs—						
Mechanical power	337,184	167,045	145,676	3,190	1,630	1,472
Other sorts	394,166	262,305	248,120	4,186	2,820	2,839
For harvesting, threshing and sorting:—						
Hay and grass mowers (including mowing attachments to tractors) other than rotary blade type	75,146	50,433	50,248	1,114	824	855
Reapers, binders and threshers	22,846	7,802	12,008	265	89	141
Combine harvester-threshers	204,211	153,451	144,440	4,016	3,196	2,784
Other	165,902	162,477	162,613	2,418	2,334	2,466
Dairy machinery	40,090	24,768	25,468	1,883	1,121	1,233
Lawn mowers	136,356	124,417	130,449	1,651	1,539	1,628
Sheep shearers and clipping machines	6,611	3,527	3,251	417	209	228
Other descriptions	125,616	86,427	74,985	2,119	1,395	1,262
Total	1,508,128	1,032,652	997,258	21,259	15,157	14,908

machinery financed by the loan will rehabilitate 37,000 acres of land and clear approximately 12,500 acres each year. It was hoped that the cumulative effect would be an increase in Peruvian annual agricultural production of 36 million dols, of which about 17 million dols. would be exported.

Similar arrangements may well be necessary in a number of other countries if the full potential market for agricultural machinery is to be developed and the more backward countries are to be assisted to realise their potentialities as food producers. Although in most cases a well planned scheme of farm mechanisation should more than pay for itself over a period of years, few farmers in underdeveloped countries, particularly if the average size of farms is small, can possibly raise the capital to acquire the necessary machinery. In some cases the Government of the country concerned is able to provide the necessary finance; in the Republic of Ireland, which possessed very little agricultural machinery at the end of the war, the Government has provided long-term loans to farmers which have enabled them to mechanise most of the large and medium-sized farms. As can be seen from Tables I and II the Irish Republic has provided a steadily increasing market for all classes of British agricultural machinery and in the first eleven months of 1954 took 4,460 tractors valued at £2·0 million and 161,930 units of agricultural machinery other than tractors, valued at £1·9 million. The potentialities of countries such as India, Ceylon and a number of Commonwealth countries in Africa are very much greater than those of the Republic of Ireland and yet their purchases of agricultural machinery are much smaller.

STEAM ENGINE USING LOCAL FUELS

Before full-scale mechanisation of farming can be undertaken in undeveloped countries there are a great many problems to be overcome quite apart from the question of finance. In many countries the size of farm is too small to permit mechanisation, though where intensive production is to be undertaken the size of farm required to justify a tractor may be very much smaller than is usually accepted, and in addition there is the problem of educating the farmers to use and care for the machinery which they may acquire. This inevitably involves a fairly long term programme. In the meantime a good deal can often be done to increase the output per man employed by the provision of cheap and simple power units, e.g., for pumping water or grinding cattle food, operations which in a backward area may absorb a very high proportion of the work potential of the population.

On farms in this country a great deal of this type of work is done by electricity or by oil engines of various types but in many areas there is a demand for a small power unit which can "live off the land" using whatever sources of fuel may be available in the locality. A small 2½-h.p. steam engine designed to meet this need has been designed by Sir Harry Ricardo for the National Research and Development Corporation and was demonstrated recently. It is designed to use as fuel coal, peat, wood, sawdust, sugar-cane trash, cotton stalks or dung and by means of a simple conversion can be adapted to burn oil or gas. Although the power output is not great it is claimed to be enough to pump sufficient water to irrigate 15 acres of land, and if harnessed to a modern sprinkler irrigation system and run for 16 hours a day this figure could be increased to 60 acres. It is expected that later models will be developed capable of delivering 5-h.p. Apart from the question of the availability of fuel it is claimed that an engine of this type is cheaper both in first cost and in running expenses than other types of mobile engines of similar power output.

MECHANISATION OF HOP AND POTATO HARVESTS

Development of new types of machinery is also of considerable importance on the home market since the full benefits of farm mechanisation cannot be achieved if certain operations continue to require a large casual labour force at certain times of the year. Under conditions of full employment such casual labour becomes increasingly difficult to acquire and when it is available, may prove extremely expensive. The position is aggravated by the raising of the school leaving age and the reluctance of many Education Authorities to allow children from school to help, for example, with the potato and hop harvests. The problems associated with the mechanisation of corn sowing and harvesting were the first to receive the attention of agricultural engineers and more recently considerable progress has been made in connection with the root crop, particularly sugar beet. Here the problem was rather wider since in addition to sowing and harvesting it was desirable to reduce the heavy hand labour required in thinning, singling and weeding. The development of machines to sow single decorticated seed combined with the use of steerage hoes has made it possible to eliminate a high proportion of the hand labour required for these operations.

During the past year progress has also been made in mechanising the hop harvest. During the year one manufacturer alone supplied 20 hop picking machines for use in the Kentish hop harvest and expected to install a further 35 in 1955. There are also other machines in use in smaller numbers and the demand is expected to grow rapidly. Apart from the difficulty in securing sufficient labour for hand picking under present conditions, the use of these machines is expected to show very substantial economies. One farmer with 40 acres of hops stated that mechanised harvesting was expected to cost about £1,000 compared with £3,000 for hand picking the previous year. On some farms hand picking is still preferred but it is nevertheless considered worth while to install a machine as a stand-by; if there are not enough pickers or if picking is held up by bad weather, the machine will help to ensure that the hops are harvested in reasonable time. Another purpose for which casual labour is employed on a large scale is the potato harvest. While potato spinners have been in common use for a great many years, it is still necessary to pick up and load the potatoes by hand. New types of potato harvesting machines have now been introduced which will lift the potatoes and load them into a trailer. Such machines are expensive, and unless they can be made available on hire are not likely to be adopted on farms growing less than say 50 acres of potatoes.

INCREASING AGRICULTURAL PRODUCTIVITY

Agricultural mechanisation has been adopted largely to meet the conditions of a declining labour force and increasing wages and in addition because it makes the farmer very much less dependent on weather conditions. If bad weather reduces the number of days on which ploughing can proceed, the greater speed of tractor ploughing gives a very much better chance of making up the loss when the weather improves. Similarly in a bad harvest the combine harvester, provided adequate grain drying facilities are available, enables work to proceed at times when harvesting by older methods would be at a standstill. Doubts have, however, been expressed as to whether the best results are being obtained from the machinery already available. It is pointed out that the amount of machinery on farms has increased nearly three times since 1939. During this period the output per man employed has increased by 30 per cent., a considerably larger increase than has been

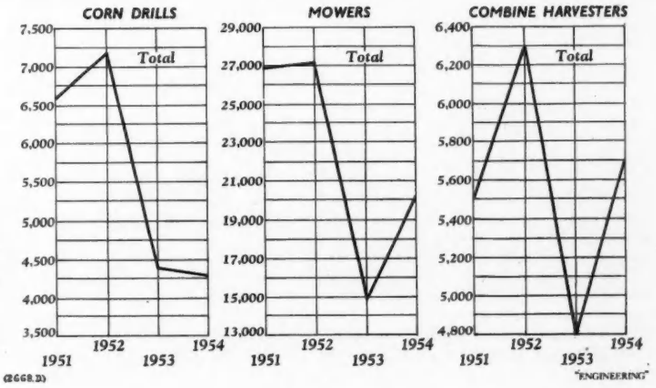


Fig. 5 Harvesting machinery made in the United Kingdom during the last four years.

achieved in industry, but a large part of the increase must be attributed to technical progress such as fuller use of fertilisers, improved seed varieties and selective breeding of higher yielding cows. The true increase in labour productivity, it is suggested, is of the order of 15 per cent. and when allowance is made for the additional labour required to produce and service the machinery in use the gain in productivity does not seem large.

Some of the reasons why productivity has not increased more rapidly have been given by the University of Cambridge School of Agriculture in a report entitled "Planning a Farm for Higher Productivity." These include the fact already mentioned above that the size of the farm staff is often determined largely by the number required at the busiest seasons of the year; in addition hours of work have been reduced and more time is spent on farm maintenance than before the war when the level of farming profits was insufficient to permit adequate maintenance, while high taxation is not conducive to maximum efficiency in labour utilisation. But the main reason suggested is that most farmers have not adapted their farming systems to make full use of their machinery. A number of ways in which this might be done are suggested for a typical farm of 158 acres in East Anglia. The acquisition of still more machinery to lighten the work at the busiest seasons of the year might permit one man to be saved, with a resultant increase in output per man employed of 26 per cent.; the inclusion of a new crop such as peas where the extra work would not coincide with the normal peak periods might give an increase in productivity of the order of 6 per cent. while an intensification of livestock enterprises might give an increase in labour productivity of 28 per cent. It is claimed that a judicious combination of all three proposals might raise output per man employed by 35 per cent.

That there is a growing realisation of the full potentialities of farm mechanisation is shown by the figures for agricultural machinery in use taken from the Ministry of Agriculture's machinery census. In the earlier years farm mechanisation was largely a question of acquiring a suitable tractor and of replacing horse-drawn ploughs, harrows and other cultivating implements by similar implements designed for tractor draught. While the number of tractors in use still continues to expand, the biggest increase is now taking place in entirely new items such as tractor-mounted loaders and pick-up balers. The rate of expansion in the use of combined harvesters slowed down slightly between 1952 and 1954 as compared with the previous two-year period but there is probably room for a further substantial increase particularly in the use of the smaller types suitable for farms with a corn acreage of, say, 50 to 100 acres.

TABLE IV *U.K. Agricultural Machinery in Use*

—	Jan., 1950	Jan., 1952	Jan., 1954	Per cent. increase, 1954 *cf.* 1952
Agricultural tractors	258,860	283,000	334,390	29
Combined seed and fertiliser drills	23,880	28,620	33,430	40
Fertiliser distributors	88,450	96,120	102,450	16
Combined harvesters	10,050	16,470	21,120	110
Pick up balers	5,020	11,430	19,990	298
Tractor mounted loaders (fork type)	1,060	7,000	12,130	1,050
Milking machines	69,170	80,750	90,740	31
Ground crop sprayers	4,190	9,330	18,260	335
Electric motors	82,920	106,790	133,910	62

HOME MARKET PROSPECTS

It will be seen from Table IV that the increase in the number of tractors in use between 1952 and 1954 at 51,390 was considerably greater than the increase of 24,140 between 1950 and 1952, which indicates that the saturation level is not yet in sight. Quite apart from the new tractor demand, however, sales of tractors are likely to be well maintained owing to high replacement demand which at present is running at an abnormally high level owing to the economies in operating costs offered by the newer Diesel models. These economies are often sufficient to justify the replacement of a petrol or vapourising oil tractor by a Diesel model long before the former would normally be considered due for replacement.

Apart from this, attempts are constantly being made to expand the demand by developing tractors for specific purposes for which they have not formerly been used. A specific example of this was the Bogmaster tractor produced by Rotary Hoes Limited, which was mentioned in this series last year. At the Scottish Industries Exhibition in Glasgow in September, 1954, a new small four-wheel tractor with mounted single-furrow plough and hydraulic lift was exhibited by the Rollo Industries Group. This was intended to meet the specific needs of the Scottish croftholder and was designed to provide adequate power and high manœuvrability on difficult sites. In addition to the plough other equipment provided for use with the tractor includes a twin-ridging plough, toolbar frame with cultivator, a disc harrow and a 6-cwt. trailer.

The provision of a complete range of implements to suit a specific tractor has been one of the outstanding features of agricultural machinery design during the last few years and was carried a stage further during 1954. In November a new agreement was announced between the Ford Motor Company, Limited, and Ransomes, Sims and Jeffries, Limited, who, since 1945, have produced certain implements specifically for Ford tractors, though Ford themselves made a limited range of ploughs and tool-bar equipment. Under the new agreement the Ford Company will cease all production of farm implements, the existing Ford designs being replaced by new ones manufactured by Ransomes who will also assume responsibility for servicing and spares for existing Ford implements. Both companies were proposing to expand production capacity, Ford plans over the next five years being expected to cost £65 million with an increase in factory floor area of four million square feet. By the end of the year Ransomes new factory at Nacton near Ipswich was nearly complete; it adjoins the modern foundry completed recently and when completed will double the manufacturing area already in use.

Earlier in the year the Ford Motor Company opened a new farm mechanisation training centre at Boreham in Essex as part of a scheme to build up a "Ford farming system" in competition with the rival "Ferguson system." In the past the Ford Company has not stressed the interdependence of Ford tractors and any particular types of implement and it is to be hoped that commercial rivalry will not result in a number of mutually exclusive sets of farming equipment (the David Brown Corporation also provides a complete range of implements for use with its own tractors). While the integral design of implements and tractors undoubtedly has many advantages there are serious dangers in carrying it to the point at which once a farmer has acquired a particular make of tractor his choice of implements is absolutely confined to those made by the group producing that tractor. He may for example require both a light and a heavy tractor and there are obvious advantages in being able to use certain implements with either. At present the commercial advantages of selling a system appear to be in danger of out-weighing the true consumer interest which will only be given full weight if some measure of standardisation is introduced permitting a certain degree of interchangeability.

In assessing the prospects for sales of agricultural machinery in the home market in the coming year much will depend on the outcome of the February price review and the extent to which farmers are encouraged to continue corn growing. The increase in wages granted in December, 1954, will cost about £12 million and although the price review in February, 1955, would normally be concerned with crop prices for 1956, the National Farmers' Union have announced that they will have to ask for a special review because of the wage increase. This presumably means that they will ask for an increase in the 1955 prices which were agreed at last year's review. Some anxiety has already been expressed that the poor harvest in 1954 may result in a reduction in capital expenditure on machinery in the coming year, and that farmers might have been discouraged by the low prices received for wheat even though these were subsequently made up to the guaranteed minimum by means of deficiency payments. It is quite possible that if deficiency payments continue to run at a high level there may develop in the long run strong pressure for a reduction in cereal prices. Since there appears little prospect of any substantial fall in major farm costs this would inevitably be reflected in a fall in the acreage under crops and a decline in the home demand for agricultural machinery. The bad harvest in 1954, however, was common to most of the principal wheat producing countries and although large surpluses still exist in North America, the steady fall in world wheat prices which continued throughout 1953 and the greater part of 1954 appears to have been halted.

Previous articles in this series have considered Britain's place in the engineering world, and manpower in Britain's engineering industries. Future articles will examine the position of other major engineering industries.

* * *

LAUNCHES AND TRIAL TRIPS

M.S. "NOONGAH."—Single-screw cargo vessel, built by James Lamont & Co., Ltd., Port Glasgow, to the order of the Australian Shipping Board, Canberra, for the Australian coastal trade. Main dimensions: 230 ft. by 37 ft. by 15 ft. 9 in.; gross tonnage, 1,200. Diesel engine constructed by British Polar Engines, Ltd., Glasgow. Launch, December 29.

M.S. "OLIVEAN."—Single-screw trawler, built by Cochrane and Sons, Ltd., Selby, Yorkshire, for Sir Thomas Robinson and Son (Grimsby), Ltd., Grimsby. Main dimensions: 115 ft. between perpendiculars by 25 ft. by 12 ft.; gross tonnage 275; fishroom capacity, 6,800 cub. ft. Four-cylinder direct-reversing Diesel engine, developing 575 b.h.p. at 225 r.p.m. in service, constructed by British Polar Engines, Ltd., Glasgow, and installed by the Drypool Engineering and Dry Dock Co., Ltd., Hull. Service speed, 11 knots. Trial trip, December 29.

M.S. "IRMA."—Single-screw cargo vessel, with accommodation for twelve passengers, built and engined by Alexander Stephen & Sons, Ltd., Glasgow, for the West African service of Det Bergenske Dampskibsselskab, Bergen, Norway. Main dimensions: 400 ft. by 57 ft. by 35 ft.; gross tonnage, about 4,550; deadweight capacity, about 6,530 tons on a draught of 23 ft. Stephen-Doxford four-cylinder two-stroke oil engine. Service speed, 14½ knots. Trial trip, December 30.

M.S. "CAPETAN PSARROS."—Single-screw cargo vessel, built and engined by Swan, Hunter, and Wigham Richardson Ltd., Newcastle-upon-Tyne, for the Tramp Chartering Corporation, Panama. Main dimensions: 450 ft. between perpendiculars by 62 ft. by 40 ft. 4 in. to shelter deck. Swan Hunter-Doxford five-cylinder oil engine, arranged for burning boiler fuel, and developing 5,500 b.h.p. at 115 r.p.m. in service. Launch, January 7.

M.S. "AGHIOS NICOLAOS."—Single-screw cargo vessel, with accommodation for four passengers, built and engined by William Doxford and Sons, Ltd., Sunderland, for the Porto Blanco Compania Naviera S.A. (Managers: Rethymnis and Kulukundis, Ltd.), London, E.C.3. Second vessel of a series of three. Main dimensions: 450 ft. between perpendiculars by 62 ft. by 30 ft. 6 in.; deadweight capacity, 11,120 tons. Doxford four-cylinder opposed-piston oil engine. Service speed, about 13¾ knots. During the trials, speeds of over 16 knots were obtained. Trial trip, January 7.

H.M.S. "RIPLINGHAM."—Inshore minesweeper, built by Brooke Marine Ltd., Lowestoft. One of a group of these vessels being constructed in the United Kingdom for N.A.T.O. nations under the United States Off-Shore Procurement Programme. They have a length of 106 ft. 5 in., a breadth of 20 ft. 6 in., are of all-wood construction, and are designed to operate in shallow waters. Launch, January 11.

HIGH-SPEED MACHINE TOOLS FOR AIRCRAFT PRODUCTION*

ROUTING, THREE-DIMENSIONAL MILLING AND SAWING

By S. Radcliffe, B.SC.(TECH.), A.M.I.MECH.E., M.I.PROD.E.†

Recently, a heavy-duty radial-arm router fitted with a 5-h.p. head was introduced to meet the need of the aircraft industry for a machine to profile alloy plates from the solid (described in ENGINEERING, page 764, vol. 178, 1954).

Experience with the machine was satisfactory, but it was obvious that if the template could be positioned above the router head, instead of being bolted directly on the work piece, a number of advantages would be obtained.

OVERHEAD-TEMPLATE RADIAL ROUTER

The prototype of such a machine, which has only been in use about three months at the works of Vickers-Armstrongs Limited, at South Marston, Swindon, with overhead template is shown in Fig. 1.

The columns and superstructure supporting the overhead template are very substantial, the columns being tied to the table and the latter to the main column of the router to get maximum rigidity and ensure continued alignment between the table and the top template carrier. This weight is essential as the guide-pin may strike the template with force, and with the weight of the moving radial arm behind it, substantial forces would be set up and the template moved in relation to the table. This would of course affect the accuracy of the machine. A heavy bracket has been fitted on the horizontal radial arm to carry a follower pin on the same axis as the centre of the cutting spindle.

TRAVERSING TABLE AND TEMPLATE

This machine was provided with a table 10 ft. long by 2 ft. 6 in. wide, arranged to traverse longitudinally. The table and the top template holder were jig bored with ½-in. template holes at 8-in. spacing to act as universal pick-up points for locating all existing profiling templates from Cincinnati Hydrotel machines, the idea being to rough out all the suitable parts on the router and finish on the Hydrotel. The use of size templates for the roughing operation did not cause any difficulty.

An arrangement is now being fitted to the machine so that the table and template can be traversed independently, or both head and template can be traversed together. The positioning is done by dividing bars fitted on the front edge of the table and on the template carrier. Powerful plungers on the table base and top frames locate them. With this arrangement it is possible, by moving the table along once, to cover a component 10 ft. by 2 ft. 6 in. using existing templates, and by roughing out to $\frac{1}{32}$ in. oversize, to remove the excess material quickly and economically.

The pin and cutter spindle must be maintained in the same vertical axis. The rise and fall of the follower pin to engage with the template is operated by a Bowden cable fixed on the right-hand operating handle. The cutter head is mounted on a " drop " slide, plunger-controlled for depth with the usual type of handle and links. In addition, a second vertical slide is provided behind the drop slide with screw adjustment and handwheel on the left-hand side of the operating position calibrated so that one turn gives a drop of $\frac{1}{8}$ in.

A more efficient and cheaper way of handling long components might be to have a fixed table, say 12 ft. long and a fixed overhead template carrier, with the router radial arm arranged to travel under power on a bed behind the table. The power is not to assist cutting, but to position the arm to cover 4 ft. by 2 ft. 6 in. area on the table and then move the unit along the bed 4 ft. to cover the adjacent area on the component. It is easier to maintain the radial arm in a horizontal plane on a substantial bed than the alignment of a travelling table and travelling overhead template carrier. A machine of this type is now being designed.

SPINDLE HORSE-POWER

It soon became apparent on the prototype machine that the 5-h.p. head was not powerful enough. A larger head of 10 h.p. has been tried for the first time in the last few days with excellent initial results. It is in practice almost three times as powerful as the 5-h.p. head. A head of 20 h.p. is now being designed capable of well over double the power of the present new one.

It is possible to take cuts as follows with the 5-h.p. head : 1 in. deep by $\frac{1}{8}$ in. at 100 in. per minute, 1 in. deep by $\frac{1}{16}$ in. at 160 in. per minute, 3 in. deep by $\frac{1}{32}$ in. at 100 in. per minute, 4½ in. deep by $\frac{1}{32}$ in. at 100 in. per minute. On the 10-h.p. heads the figures are : 1 in. by $\frac{1}{4}$ in. at 66 in. per minute, 1 in. by $\frac{3}{8}$ in. at 64 in. per minute, 1 in. by $\frac{1}{2}$ in. at 55 in. per minute, 1 in. by $\frac{3}{8}$ in. at 48 in. per minute, 3 in. by $\frac{1}{16}$ in. at 100 in. per minute, 4½ in. by $\frac{1}{16}$ in. at 50 in. per minute.

It is probable that after some experience of the 10-h.p. head, cutters can be designed that will remove more metal.

It is obviously desirable to be able to power-control the feed of this type of machine. The most promising method is the use of two cylinders at right angles anchored on the supporting columns of the overhead template on the fixed-column machine shown in Fig. 1. Their intersection point can be anchored immediately behind the cutter-spindle axis and the amount of error involved would probably not be serious.

SUPPORTING THE ROUTER HEAD

Hitherto the horizontal sliding arm on a rotating barrel has been used successfully for all standard applications of the radial router. Now, however, it is necessary to work to as close limits as possible on the bottom of the cutter in a true horizontal plane for finishing the bottoms of pockets and face-milling crank-cases, etc. To achieve this there appear to be three possibilities:

(*a*) Using the existing type and improving its mechanical design by redesigning the frame, arm and suspension to get increased accuracy. This is now being done.

(*b*) Experimenting with a double-arm radial using precision preloaded bearings. This type has been in general use in the United States for many years. A test machine of this type, illustrated in Fig. 2, has been constructed for experimental investigation. This arrangement gives a bigger radius of action although the sag on the cutter point is not yet known.

(*c*) A gantry-type machine, comprising a fixed table, with beams on either side of the table, supporting a rolling girder across the work on which is mounted a router head moving across the girder. Such a machine is being used at the present time for some applications.

(*d*) A combination of (*a*) and (*b*). This type of machine was made and used in the airframe

* Lecture presented at the Conference on Aircraft Production Problems, on Saturday, January 15. Abridged.

† Technical Director, Wadkin Limited, Leicester.

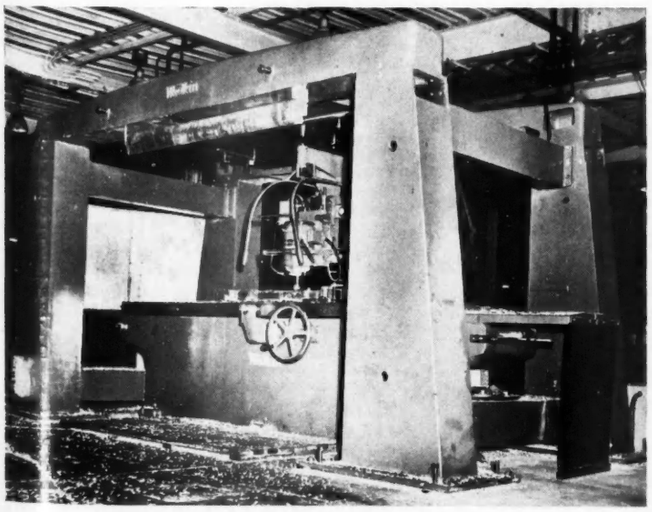


Fig. Heavy-duty radial-arm router for light alloys with overhead template the 10 ft. by 2 ft. 6 in. table is arranged to traverse so that work longer than the compass of the radial arm can be accommodated.

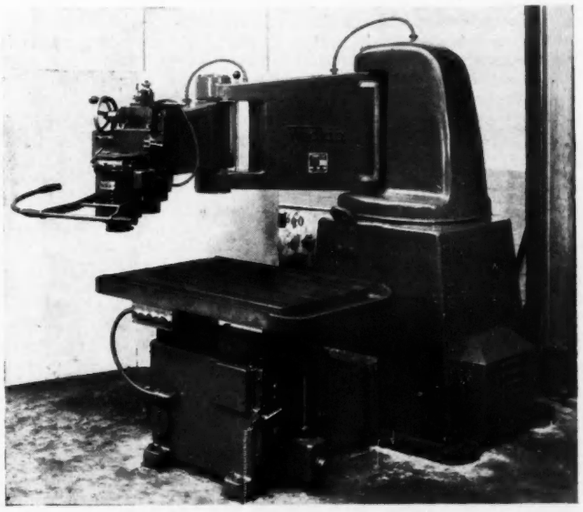


Fig. 2 Experimental double-arm radial router with precision preloaded bearings. This arrangement gives a larger radius of action.

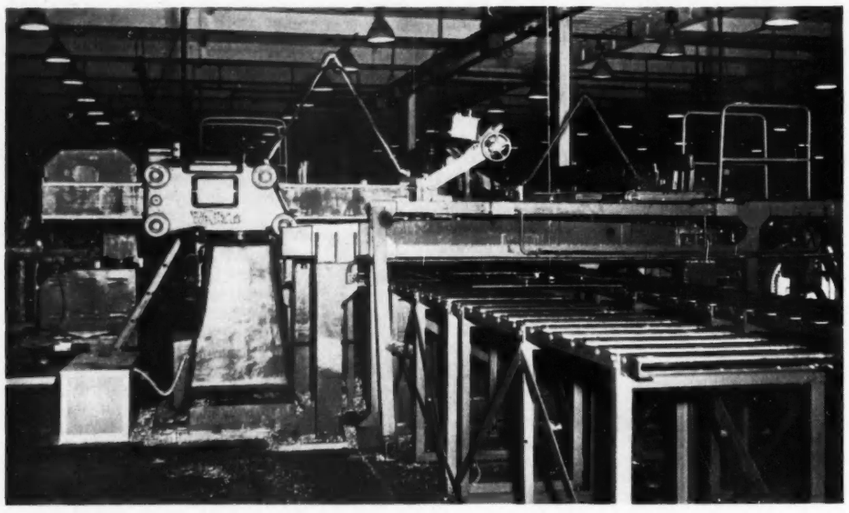


Fig. 3 (See caption to Fig. 5)

Fig. 4 Light-alloy skin produced on the skin-milling machine illustrated in Figs. 3 and 5. By using vacuum chucks skin thicknesses to within ± 0·002 in. can be obtained.

industry for big-reach work on built-up sheets, years ago.

CUTTER DESIGN

All pocketing cutters are tungsten-carbide tipped. Short profiling cutters up to about 2½ in. long of the straight-flute pattern cut more freely than the quick spiral, but cannot be held up to the template above this depth (2½ in.). From this depth up to the present maximum of 4½ in., a quick spiral gives smoothest cutting and best results.

The removal of the metal in the centre of a large internal pocket without a guide can be slower than when using a guide plate. To eliminate this difficulty, an air-operated lock has been fitted to the sliding arm, which gives the equivalent of a radial guide template, which speeds up the operation appreciably. The air-lock release is operated by a press button on the operating handle so that no time is lost in this operation.

LUBRICATION

In view of the rate of metal removal possible with more powerful heads, lubrication by brushing the workpiece is too slow. An oil mixture and a jet of compressed air have been used experimentally and have proved very satisfactory. Both the oil volume and the air pressure are variable at the operating position, and satisfactory oil-mist lubrication can be obtained for all types of cutters. The use of a small amount of molybdenum disulphide at about 1 in 500 has given good results; cutting oils containing the sulphide, suitable for routing duty, are available. Pocketing cutters using molybdenum disulphide lubricants are running continuously for over a week on production without being touched or removed by the operator.

It appears that with the increased power available, hand honing of the cutters is not so important, and good machine-finishing is sufficient for good working at 12,000 r.p.m.

Fig. 5

Figs. 3 and 5 Skin-milling machine for light alloys based on two radial-arm routers supported on a ball-bearing gantry. The operator is seated on a bridge across the work, which is held on the work table by vacuum chucks.

SKIN MILLING

A skin milling machine based on two radial routers, installed at Vickers-Armstrongs Limited, is illustrated in Figs. 3 and 5. The principle of this machine, it may be recalled, was described by Mr. S. P. Woodley (Vickers-Armstrongs, Limited) at the previous conference (ENGINEERING, page 7, January 1, 1954). Two special radial arms are used, one on each side of the table to cover a skin 6 ft. wide; any length can be handled by moving up. The arm is supported on a ball-bearing gantry, to eliminate any sag of the head, and accurately controls the depth over an area of 3 ft. by 3 ft. The operator is seated in a chair, bridge-mounted across the work with power forward and reverse drive, operated by pedals, as shown in Fig. 5. In this way, he is always close to his cutter and has a comfortable operating position. With this equipment it is possible to get skin thickness to about ±0·002 in. over an area of 30 in. by 30 in. using vacuum chucks on the table. A finished skin produced on this machine is shown in Fig. 4.

Another method incorporating power feed and compressed-air loading of the follower pin to the template, is under consideration, in which a fixed table and an overhead gantry carry a cross slide on which is mounted a router head of 20 h.p. Power feed is provided along the length working in conjunction with double-acting pneumatic cylinders at right angles to the feed to keep the guide roller up to the profile plate. Similar feed is provided across the table with pneumatic hold ups, so that the operator can follow the profile roller by manipulating switches. This application is only two-dimensional, but it represents a step forward in getting power feed to a skin 16 ft. by 5 ft. at a modest cost. Because only a router is used the stresses set up in the machine will be small and a relatively light construction will give the required accuracy.

By using a series of superimposed templates, stepped pockets and a tapered skin can be obtained by suitable packing on the table.

UNIVERSAL MILLING MACHINE

The three-dimensional milling machine illustrated in Fig. 6 has been designed for light-alloy cutting and the prototype will be finished in the next few weeks. It is an open-side design capable of high feeds and speeds.

The longitudinal traverse is on the table, and the cross traverse of the cutter head on the cross beam. In addition the table has power feed rotation, and the spindle head cants through 120 deg. from 15 deg. left through vertical to 15 deg. below horizontal right. The spindle is quill mounted, having 3½ in. of down feed, so that angular boring and milling can be done, in addition to 12 in. of power feed in a vertical plane on the intermediate slide.

The machine will take work up to 5 ft. long by 3 ft. wide by 3 ft. high or circular work up to 5 ft. diameter and up to 7 ft. diameter for simple circular milling operations. Eight plunger locations are provided at 45 deg. for setting the table.

The spindle headstock has a 5-h.p. head fitted with 18 speeds, from 135 to 6,000 r.p.m., the lower range through gear drive and the higher range on belt with no gears in mesh. Power traverses 6-in. to 180-in. per minute are offered on table traverse and rotation $\frac{1}{10}$ to 1 r.p.m. cross feed to spindle (3 in. to 90 in.) and down feed (½ in. to 12 in.) to spindle. Capstan stop bars are fitted to all head and table movements for small-quantity repetition work.

The machine is arranged for hand profiling,

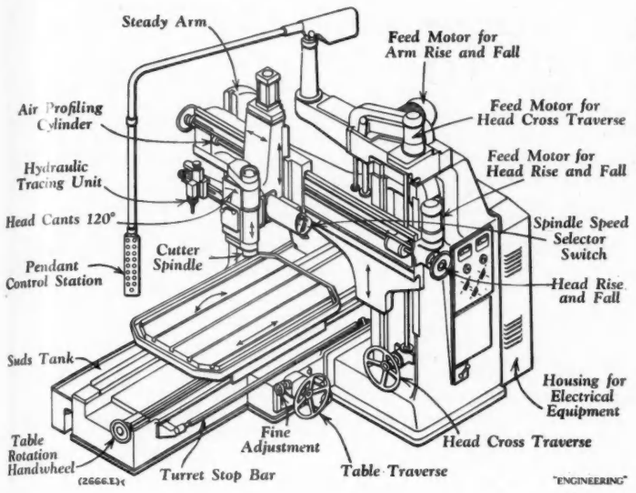


Fig. 6 Universal milling machine now under construction for large light-alloy components. It has cutting speeds ranging from 135 r.p.m. to 6,000 r.p.m.

using a profile plate on the component and using the two traverse handwheels for the table and the cross-slide of the spindle, which are adjacent to each other for the convenience of the operator. In addition, power profiling can be done, using a pneumatic control to keep the cutter follower mounted on the spindle up to the template. The cutter-head is arranged to float on the horizontal arm and can be coupled to a pneumatic cylinder. built into the arm itself for this operation. By using this device and the down traverse of the table, it is possible to profile up to the length of the machine with a variation in depth of profile of the stroke of the pneumatic cylinder (9 in.). Alternatively, the rotating table can be used for work of a fairly circular nature (up to 9-in. variation of radius) in the same way as for 360-deg. profiling.

The machine is also offered with hydraulically-controlled depth copying, a stylus attachment being fitted side by side to the cutter spindle on the horizontal arm . When this equipment is used components up to 5 ft. by 18 ft. wide can be worked on the table. Alternatively, by turning the table at right angles, work up to 2 ft. 6 in. by 3 ft. can be accommodated. In addition, the tracer can be used vertically in conjunction with the spindle positioned horizontally for milling short profiled spars. The machine is offered with a removable outboard steady. When this is removed, the machine is open on three sides, so that very large limbs can be accommodated as required.

Double rotary copying tables for work up to 2 ft. 6 in. diameter are also offered, power operated, for applications where a rotary feed is preferable to longitudinal feed.

The longitudinal table traverse, the rotary movement of the table and the cross slide carrying the spindle are all mounted on multiple-precision rollers, making the machine very light to operate on the hand traverse and facilitating the profiling operations mentioned above. The power traverses are obtained from small Ward Leonard sets and infinitely variable direct-current motors giving a wide range of feed speeds.

A further advantage in operation is the duplication of controls on both sides of the machine and, with the swing-over pendant, the operator working from one side or the other can always see clearly exactly what he is doing; in addition, he can if he wishes, index his table through 180 deg., and continue without changing his operating side. The machine is equipped with oil-mist cutter lubrication if required.

SPAR MILLING MACHINES

Fig. 7 illustrates a new spar milling machine which is being prepared specifically to meet the needs of the British aircraft industry. It is of the bridge type, for additional rigidity. The outboard arm is easily removable for occasional work of large size where the steady would be in the way. The pivot point of the canting horizontal spindle has been chosen with care to make the design calculations of the canting copy bar as simple as possible. Vertical and horizontal slides in front of the canting slide mechanism make it possible to position the bottom centre cutting point of the cutter to the correct datum point, to compensate for loss of cutter diameter due to cutter grinding and other factors. It is proposed that the canting and rise-and-fall mechanisms should be controlled by two independent hydraulic servo-mechanisms which will keep the copy bars light and simple as possible. Provision is made for carrying the copy bars at the rear of the machine, a set of three being necessary for profile and cant of the horizontal and cant of the vertical spindle.

Directly coupled to the horizontal spindle will be a change pole motor, giving 60 h.p. at 3,000 r.p.m. down to 10 h.p. at 750 r.p.m.; a reduction gear is also fitted to give a range of speeds of 30 up to 500 r.p.m. on a second spindle. Any spar milling machine today should be capable of cutting high-tensile steel as well as aluminium, and this machine should do both in a satisfactory manner.

The machine is also offered with a vertical router spindle, canting 10 deg. forward and backwards about the centre of the cutting edge of the cutter. The spindle unit will be equipped with 20 h.p. at 10,000 r.p.m. The unit is mounted on the main horizontal spindle head-stock, so that it will rise and fall as required on the main servo. The unit is also equipped to move forward and backwards from the operating position to give in-and-out copying up to 9 in. pneumatically controlled, the pressure required being very small because of the router speed of the spindle. From this, it will be seen that three copy bars can be used on this head to rise and fall (hydraulic), move in and out (pneumatic) and to cant (hydraulic). The machine is equipped with a table 24 in. wide.

If the machine is required for downcutting, in the majority of cases there may be distinct advantages in building the machine so that the horizontal cutter head is on the extreme left-hand of the headstock looking at the front of the machine. This would greatly facilitate the exhausting of chips on the machine.

A further addition to the spar mill worthy of consideration is a radial-arm router unit mounted on a power-operated travelling saddle on the machine bed. With this unit and drop-on templates on to the spar mill fixtures, tapering operations and possibly additional pocketing operations could be carried out at the one setting of the spar.

SAWING BILLETS AND HONEYCOMB

A large sawing machine will be made in the immediate future to handle billets 45 ft. long by 10 ft. wide and up to 5-in. thick. The machine will operate with carbide-tipped saws 44 in. in diameter driven by a 75-h.p. motor and feeds up to 10 ft. per minute.

The material is fed into the machine on conveyors arranged in three banks, separately controlled as required, so that the material can be manœuvred into alignment for sawing. The offcut is removed in the same way either sideways from the saw carriage or down the mill in line with the machine bed. Clamping is done by a series of hydraulic units built into a bridge-type beam.

The swarf is exhausted by a drag-link conveyor capable of removing 120 cub. ft. of swarf per hour, running on to a belt elevator to lift the swarf from the pit into mobile bins.

A problem still to be settled is the sharpening of the saws. The best results, of course, are achieved by using a grinding attachment on the saw machine with the saw mounted in position, but until the life of a carbide saw between grinds has been established it is not possible to determine whether grinding on the machine is economic or whether the saw will have to be removed for sharpening.

The band-sawing of expanded honeycomb material has been investigated in the past few months. After many failures it was found that a taper saw section gave best results. The teeth require to be sharp and square-faced and run at a speed of about 8,000 ft. per minute or more. Unsupported material up to about 9-in. deep has been cut successfully.

A bigger problem is to make cuts 4 ft. or more across and, if possible, generate controlled curves for shaping the material to aerofoil sections. To facilitate this, the work is probably best done using a horizontal saw. If the material can be boxed in a container, the additional rigidity will help the cutting action very considerably.

The material is mounted on a fixed table, if possible in a frame, and the horizontal blade is traversed over the material, controlled by two cams giving the required shape.

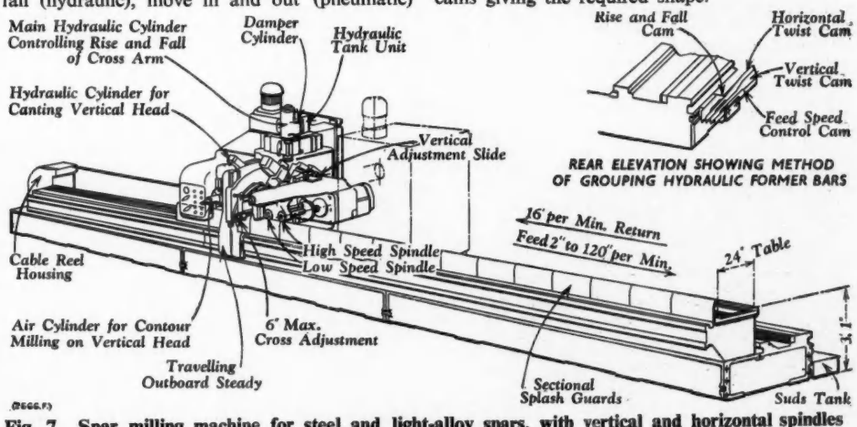

Main Hydraulic Cylinder Controlling Rise and Fall of Cross Arm
Damper Cylinder
Hydraulic Tank Unit
Hydraulic Cylinder for Canting Vertical Head
Vertical Adjustment Slide
Rise and Fall Cam
Horizontal Twist Cam
Vertical Twist Cam
Feed Speed Control Cam
REAR ELEVATION SHOWING METHOD OF GROUPING HYDRAULIC FORMER BARS
16" per Min. Return
Feed 2" to 120" per Min.
24" Table
Cable Reel Housing
High Speed Spindle
Low Speed Spindle
Air Cylinder for Contour Milling on Vertical Head
6" Max. Cross Adjustment
Travelling Outboard Steady
Sectional Splash Guards
Suds Tank

Fig. 7 Spar milling machine for steel and light-alloy spars, with vertical and horizontal spindles arranged for twist milling.

THE ULTIMATE STRENGTH OF THICK-WALLED CYLINDERS SUBJECTED TO INTERNAL PRESSURE

2—TEST RESULTS AND THEIR RELATION TO ULTIMATE-STRENGTH EQUATIONS*

By B. Crossland, M.SC., PH.D., A.M.I.MECH.E., A.F.R.AE.S., *and J. A. Bones*, B.SC., G.I.MECH.E.

TENSION TESTS

Table II gives the ultimate tensile stresses, f, determined from the tension tests. The variation of mean ultimate tensile stress with position of the specimen in the bar cross-section corresponds with the variation in analysis already noted.

Specimens N 1 and N 2 gave an average plastic yield stress of 16·4 tons per sq. in., and P 4 gave 16·9 tons per sq. in. This difference again corresponds to the variation in analysis across the bar.

TABLE II.—*Tension Test Results*

Specimen	Diameter, in.	Position	Ultimate tensile stress, tons per sq. in.	Mean ultimate tensile stress, tons per sq. in.
M 1	0·2500	Transverse through centre	32·0	32·0
O 1	0·2530		31·8	
P 2	0·2510		32·1	
O 3	0·2518	Longitudinal along centre line	32·2	32·2
P 5	0·2488		32·1	
P 1	0·2502	Transverse offset 0·44 in. from centre	33·1	32·9
P 3	0·2503		32·7	
N 1	0·3512	Longitudinal offset 0·5 in. from centre	33·3	33·2
N 2	0·3518		33·1	
I 3	0·2502	Longitudinal offset 0·7 in. from centre	34·4	34·1
O 2	0·2530		34·1	
O 4	0·2498		34·2	
P 4	0·2515		33·6	
P 6	0·2512		34·1	

TORSION TESTS

The results of the torsion tests on 35 specimens were also found to depend on the position of the specimen in the bar cross-section. Therefore, in Figs. 13 and 14, the results are shown as three separate curves corresponding to the specimen positions shown. The scatter of the results about each of the curves does not exceed ± 1 per cent. Shear stress/strain curves are derived from the experimental curves by the graphical method suggested by Nadai[11] and experimentally verified by Swift[12] and Morrison.[18]

* The first of the two parts of this article was published on page 80 of the issue of January 21. It gave a review of the various equations for the ultimate strength, information on the test specimens and the material from which they were made, and details of the apparatus for producing very high pressures.

PRESSURE TESTS

Table III gives the ultimate pressures of 13 cylinders tested, and these results are plotted in Fig. 15. Table III also gives the fluid used to transmit the pressure in each test. The preliminary tests were made at a time when the high-pressure hand pump was being used for another research on the leakage of various oils through plain glands. These oils proved to be unsuitable for pressure testing as they became very viscous at high pressure. Since the pressure gauge was nearer the pump than the specimen, this increase in viscosity would cause the pressure at the gauge to be higher than that inside the specimen; so the ultimate pressures obtained in the preliminary tests, particularly for cylinders 3, 4 and 6, are certainly higher than the true ultimate pressures. Castor oil/Lockheed brake fluid mixture and paraffin were both found to be satisfactory high-pressure fluids up to 40 tons per sq. in.

TABLE III.—*Results of Pressure Tests on 13 Cylinders*

Cylinder No.	K	Ultimate pressure, tons per sq. in.	Fluid used	Comments
1	1·572	15·5	Shell Tellus 15	Preliminary test
2	1·331	9·32	Paraffin ..	—
3	1·998	22·3	Castor oil ..	Preliminary test
4	2·290	27·0	Shell Tellus 15	,,
5	2·660	30·05	Paraffin ..	—
6	1·775	19·2	Castrol XL ..	Preliminary test
7	2·904	32·65	Paraffin ..	—
8	1·876	20·1	Paraffin ..	—
9	2·482	28·7	Paraffin ..	—
10	3·179	35·0	Castor oil plus Lockheed brake fluid	—
11	2·130	23·9	Castor oil plus Lockheed brake fluid	—
12	3·602	38·0*	Castor oil plus Lockheed brake fluid	Leaks developed in the region of peak pressure
13	3·717	39·5	Castor oil plus Lockheed brake fluid	—

* ± 1½ per cent.

The pressure/expansion curves for several cylinders are shown in Fig. 16. Fig. 17 shows the diametral expansions at the centre and ends of the cylinder gauge length for each pressure step as the pressure passed through the ultimate. Two sets of results are illustrated and they demonstrate that there was no localised bulging before the ultimate pressure was reached,

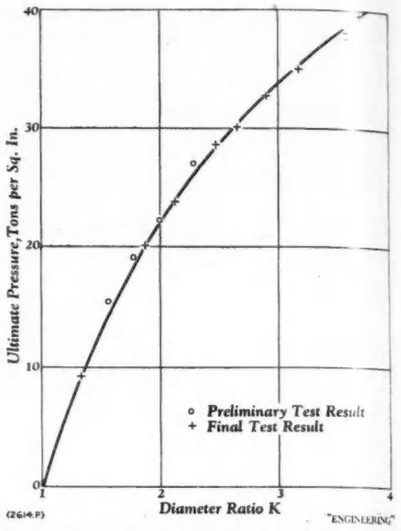


Fig. 15 Pressure tests: ultimate pressure plotted against diameter ratio for the 13 cylinders tested.

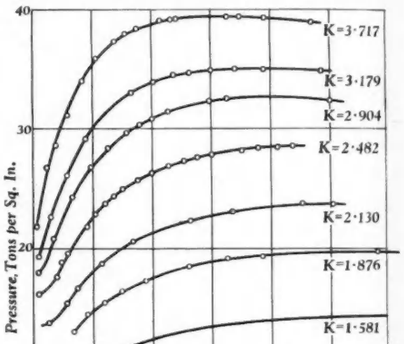


Fig. 16 Experimental pressure/expansion curves for several of the cylinders tested.

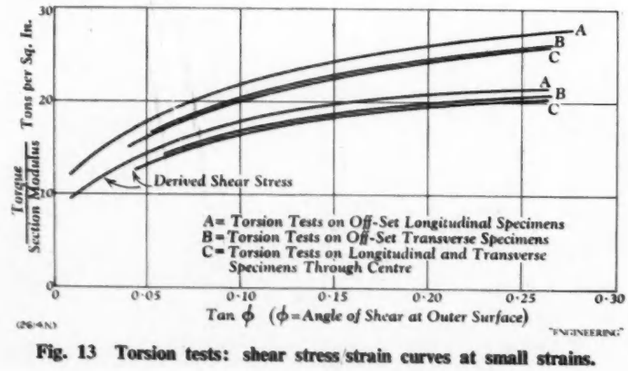

Torque / Section Modulus Tons per Sq. In.
Derived Shear Stress
A= Torsion Tests on Off-Set Longitudinal Specimens
B= Torsion Tests on Off-Set Transverse Specimens
C= Torsion Tests on Longitudinal and Transverse Specimens Through Centre
Tan φ (φ = Angle of Shear at Outer Surface)
"ENGINEERING"

Fig. 13 Torsion tests: shear stress/strain curves at small strains.

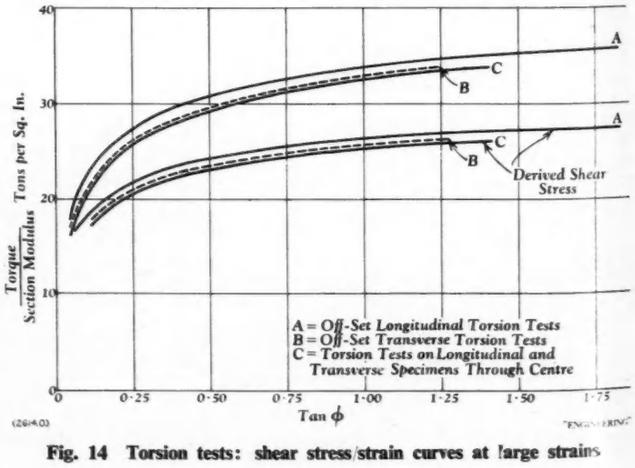

Torque / Section Modulus Tons per Sq. In.
Derived Shear Stress
A = Off-Set Longitudinal Torsion Tests
B = Off-Set Transverse Torsion Tests
C = Torsion Tests on Longitudinal and Transverse Specimens Through Centre
Tan φ
"ENGINEERING"

Fig. 14 Torsion tests: shear stress/strain curves at large strains

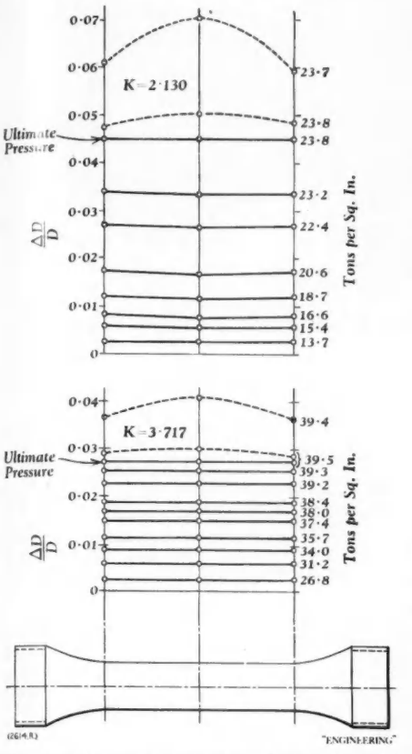


Fig. 17 Diametral expansion along the gauge length of two test cylinders, showing absence of localised bulging before ultimate pressure was reached.

indicating that there was no significant end effect for the form of cylinder used.

Results of axial strain measurements for three cylinders are plotted in Fig. 18. It will be seen that some plastic axial strain occurred and that the strain increased more slowly as the ultimate pressure was approached, increasing rapidly when this pressure was reached. The axial strains in the elastic part of the tests agreed with the theoretical values given by $\frac{P}{E}\left(\frac{1-2\rho}{K^2-1}\right)$, where P is the pressure, E is Young's Modulus and ρ is Poisson's ratio, as will be seen from Fig. 18.

FORM OF FRACTURE

All the cylinders burst fractured in a direction parallel to the cylinder axis. A typical fracture is illustrated in Fig. 19.

Fracture started in the central section of the cylinder as a failure in shear along a spiral path inclined approximately at 45 deg. to successive radii. This shear failure spread axially for a short distance and then changed into a brittle radial cleavage fracture. According to Nadai[11] the change from shear to cleavage failure occurs when the velocity with which the crack spreads becomes very high, and the change may be delayed by reducing the energy in the high-pressure system.

Cylinder No. 4 was sectioned in the directions shown in Fig. 20 and photographs of these sections shown in Fig. 21 illustrate the above points. Section AA shows the spiral shear fracture at the central cross-section of the cylinder. Section BB shows the radial cleavage fracture which developed from the shear fracture. Sections CC and DD show the change from shear to cleavage fracture in longitudinal section.

In cylinder No. 10 (K = 3·179), fractures started simultaneously at two points, and in spreading connected up and caused a piece of the cylinder wall to be dislodged. This is illustrated in Fig. 22.

In Fig. 21, sections CC and DD, and in Fig. 22, axial cracks in the bore, which are

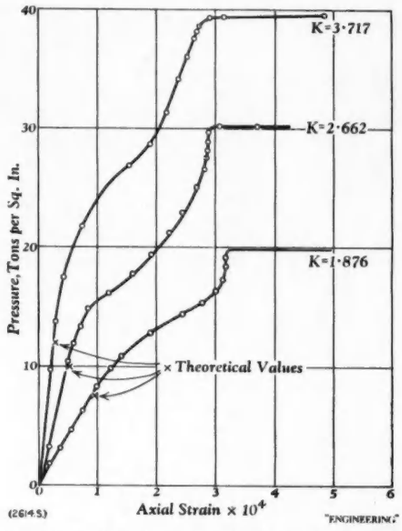


Fig. 18 Axial strain in three of the cylinders.

subsidiary to the main fracture, can be clearly seen (particularly at B in Fig. 22). In none of the cylinders tested were subsidiary cracks visible on the outer surface. This demonstrates that failure is initiated at the bore, which is contrary to the experimental evidence provided by Bridgman[14] and Michels.[15] It should be noted, however, that their results were obtained on cylinders of larger K (K = 7).

INTERPRETATION OF RESULTS

The tension and torsion tests revealed that the material had no variation of properties with longitudinal position in the bar but considerable variation of properties with radial position in the bar. In calculating the theoretical ultimate pressures from each of the various relations set out in the introduction, three sets of results have been derived, based on tension or torsion results for specimens: A, offset longitudinal; B, offset transverse; and C, longitudinal and transverse through centre of bar. Thus the effect of this variation in properties may be seen.

Now the walls of the thick cylinders lay between an outer radius of 0·5 in. and an inner radius which varied from 0·375 in. (cylinder No. 2) to 0·135 in. (cylinder No. 13). It is considered therefore that the tension and torsion

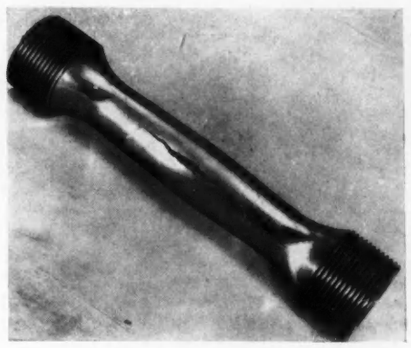


Fig. 19 Form of fracture for cylinder No. 1 (K = 1·572), which is typical of the thick cylinders burst by internal pressure.

properties of the material of the cylinder walls lay between those of specimens B and C above, and that the experimental ultimate pressures should be compared with theoretical ultimate pressures lying between those based on specimens B and those based on specimens C.

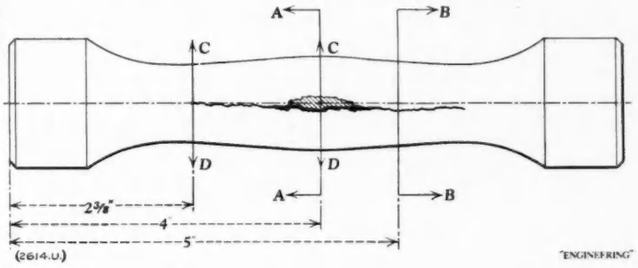
In Figs. 23, 24 and 25, the experimental ultimate pressures are compared with the curves for each of the three empirical equations (1), (2) and (3) which are based on ultimate tensile strengths. In Fig. 26 the experimental ultimate pressures are compared with curves given by Manning's ultimate pressure theory calculated on the torsion results. Manning's theory also enables pressure/expansion curves to be constructed, and in Fig. 27 pressure/expansion curves have been drawn for three cylinders and compared with the corresponding experimental results.

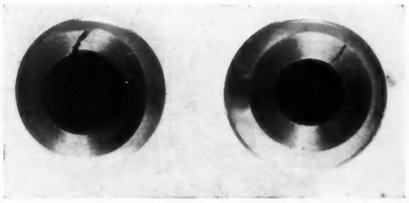
DISCUSSION OF RESULTS

From Figs. 23 and 24 it will be seen that the empirical equation (1) of Cook and Robertson, and Blair's equation (2), are not supported by the results of the experiments described in this paper. This confirms that Blair's equation is no more than an empirical relation without true theoretical basis.

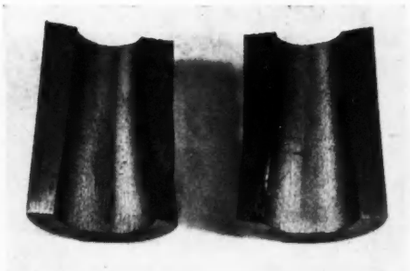
Ultimate pressures have been calculated from the equation of Cook and Robertson and Blair's equation for the tests of Faupel and Furbeck, and Deffet and Gelbgras, but again there appears to be no agreement with the experimental results, especially at large K. (It should be noted that Deffet and Gelbgras give the ultimate

Fig. 20 Showing method of sectioning a burst cylinder to give Fig. 21.





Section AA Section BB



Section CC Section DD

Fig. 21 Details of fracture revealed by sectioning a burst cylinder as shown in Fig. 20.

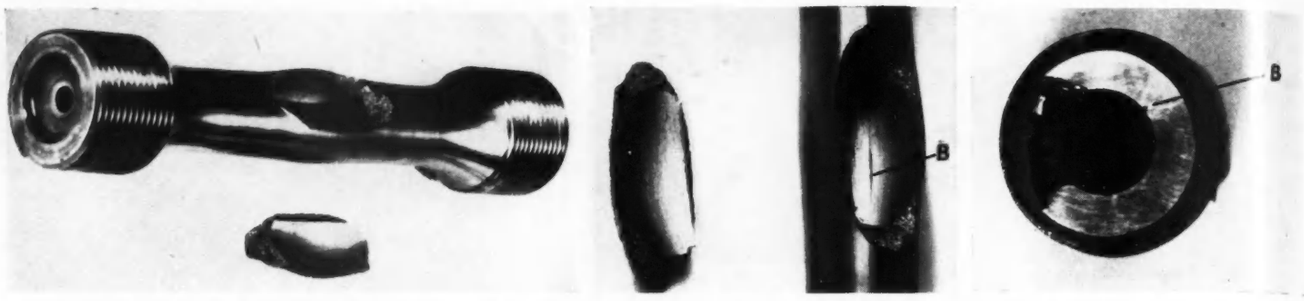


Fig. 22 An unusual and dangerous type of burst. Fractures started simultaneously at two points and in spreading joined up and caused a piece of the cylinder wall to be dislodged.

pressure of a mild-steel cylinder having K equal to 2·467 as greater than 31·9 tons per sq. in., this result being quite inconsistent with their ultimate pressures at smaller K. The present authors consider that in obtaining this result the fluid used must have frozen.)

Fig. 25 shows that the agreement between the experimental results and the ultimate pressure curves for the mean-diameter formula (3) is good. The ultimate pressures predicted by the mean-diameter formula are slightly low, since the experimental results should lie between curves B and C. It cannot, however, be assumed that the mean-diameter formula is generally applicable to ductile materials as it has no theoretical justification. In addition, there is reason to believe the agreement obtained in the present tests may be fortuitous since the experimental results of Faupel and Furbeck, and Deffet and Gelbgras do not support the mean-diameter formula.

The empirical equation (4) suggested by Faupel and Furbeck has been calculated for the cylinders tested in this research, and the predicted ultimate pressures are between 11 per cent. and 6 per cent. low. As already noted their own experimental results did not support equation (4) either.

The ultimate pressures calculated from equation (5) give errors which vary from 3 per cent. to 10 per cent.

MANNING'S THEORY JUSTIFIED

Finally, from Fig. 26 it will be seen that the agreement between the ultimate pressures calculated from Manning's theory and the experimental results is very good. Comparing the experimental results with a theoretical curve between curves B and C, it is seen that the theory gives ultimate pressures which are slightly high. Two causes contributory to this error are:

(i) Variation of cylinder wall thickness. Because of machining difficulties with the material used, the wall thickness of the cylinders, especially the higher K cylinders, may have varied owing to bore eccentricity. To check this, the cylinder having the largest K was tested to just beyond its ultimate pressure and then sectioned and checked for bore eccentricity. K was found to vary from 3·697 minimum to 3·735 maximum, which would not completely account for the error.

(ii) Incorrect expression for shear strain in Manning's theory. The authors consider that in Manning's theory, considering the order of the strains involved, comparisons of shear stress and strain between cylinder and torsion specimen should be made on the basis of octahedral shear strain. The octahedral shear strain for the cylinder is $\sqrt{\frac{8}{3}} \log_e \frac{r}{r_0}$, where r_0 is the original radius and r the radius after straining; and for the torsion specimen is $\sqrt{\frac{2}{3}} \tan \psi$, where ψ is the angle of shear at the outer surface of the specimen. Then the shear stress in the cylinder equals the shear stress corresponding to $\sqrt{\frac{2}{3}} \tan \psi = \sqrt{\frac{8}{3}} \log_e \frac{r}{r_0}$ for the torsion specimen. Making the alteration to the Manning theory has no significant effect at low values of K and lowers the theoretical ultimate pressure at K = 4 by only ½ per cent. It should be noted, however, that it would lead to a more significant difference for higher values of K or if the strain hardening at large strains were greater.

From Fig. 18 it is seen that there is axial plastic flow which, though small compared with the circumferential plastic flow, will give rise to some small difference between the experimental ultimate pressures and those predicted by the Manning theory. It has not been possible to calculate the quantitative effect of this axial flow.

The Manning theory, which is the only theory so far produced which enables the strains to be calculated as well as the ultimate pressure, is also substantiated by the agreement between the theoretical and actual pressure/expansion curves shown in Fig. 27.

Unfortunately, none of the published papers which gives experimental ultimate pressures gives also the shear properties of the material used, so that it has been impossible to check if the Manning theory is supported by these results. It is considered by the authors that the Manning theory is the only one so far published which is based on logical reasoning, and the present results offer very strong confirmation of this theory.

SUMMARY OF CONCLUSIONS

The tension and torsion tests carried out on the material indicated no longitudinal variation in properties but radial variation in properties corresponding to the radial variation in analysis. From these tests it was possible to know the properties of the material which formed the walls of the test cylinders to a good degree of accuracy.

From measurements of the expansion at various cross-sections in the gauge length of cylinders under test it can be concluded that for the cylinder form adopted the massive ends of the cylinders had no significant effect on the ultimate pressures measured. This is in agreement with the conclusions of Cook and Robertson.

The ultimate pressure results for cylinders with K of up to 3·72 provide strong evidence that the theory suggested by Manning is essentially correct. The experimental results lie slightly below the curve predicted by Manning's theory, but very small inaccuracies in the theory and the experimental results have been shown to contribute to this error. Measurements have shown that Manning's assumption that the axial strain is always negligibly small compared with the circumferential and radial strains is a very good approximation. The pressure/expansion curves predicted by the theory are in very good agreement with the experimental results.

There is good agreement between the ultimate

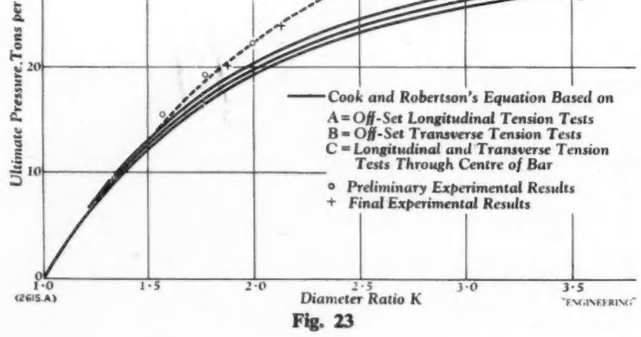


Fig. 23

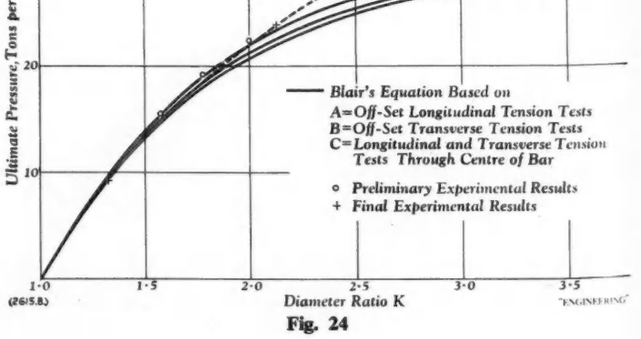


Fig. 24

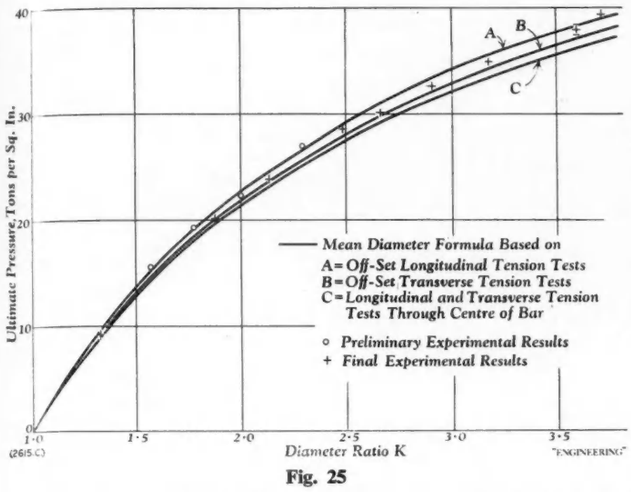


Fig. 25

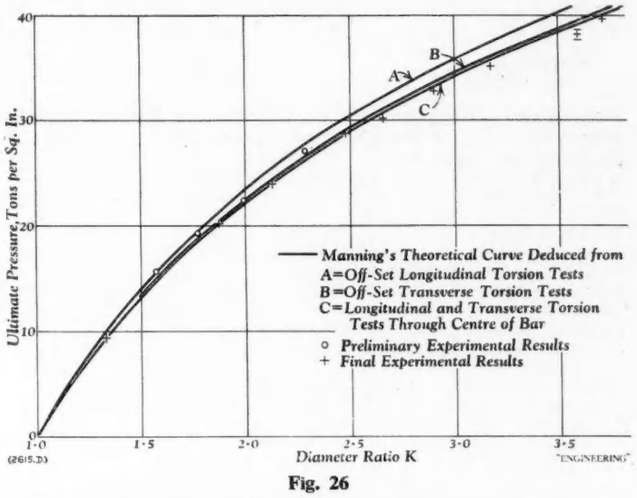


Fig. 26

Figs. 23-26 Experimental ultimate pressures compared with curves based on empirical formulæ and Manning's ultimate-pressure theory.

pressure results and the mean-diameter formula for estimating ultimate pressures. The authors consider, however, that this may well be fortuitous, especially as this formula is not supported by other published experimental results.

None of the other empirical ultimate-pressure formulæ suggested has been substantiated by the present experimental results and they are not supported by other published results.

From examination of the fractures in the cylinders burst it is evident that rupture commences at the bore of the central section of the gauge length of the cylinder as a failure in shear. This failure spreads both axially, parallel to the centre-line of the cylinder, and through the cylinder wall, following a 45-deg. spiral path. As it spreads this central initial shear failure changes, at a point determined by the energy in the high-pressure system, to a radial cleavage fracture parallel to the cylinder axis.

The apparatus developed for these tests has proved entirely satisfactory for pressures up to 46 tons per sq. in. The only leakage from the system is past the piston of the dead-weight gauge; at 42 tons per sq. in. and with minimum high-pressure volume this leakage gives a pressure drop of only 0·02 ton per sq. in. per minute. No leakage from the high-pressure cocks has been detected and it has proved possible to shut these without difficulty. In use, the dead-weight gauge has proved to be delightfully sensitive.

One of the authors intends to extend this work to cover cylinders of larger K and other ductile materials, and also to carry out tests on the effect of the ends of the cylinder on ultimate pressure.

ACKNOWLEDGMENTS

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APPENDIX

Manning's Theory for Predicting the Pressure/Expansion Curve

Manning's theory applies to cylinders in which the overall strains are such that the elastic components of these strains are negligible. By considering the radial equilibrium of an element in the wall of the cylinder, it can be shown that for large or small strains the internal pressure P is given by

$$P = 2\int_{r_i+u_i}^{r_o+u_o}\left(\frac{S}{r+u}\right).d(r+u) \quad . \quad (6)$$

where u_o is the increase in the outer radius r_o; u_i is the increase in the inner radius r_i; u is the increase in an intermediate radius r; and S is the maximum shear stress $\frac{t-p}{2}$ at the radius $(r+u)$; where t is the tangential stress at radius $(r+u)$; and p is the radial stress at radius $(r+u)$.

If it is assumed that there is no change of volume during the plastic expansion of the cylinder, and that the axial strain is negligible, it may be shown that

$$2\,u\,r + u^2 = 2\,u_i\,r_i + u_i^2 = C^2 \quad . \quad (7)$$

where C is a constant. Then the maximum shear strain σ at a radius $(r+u)$ is given by

$$\sigma = \tfrac{1}{2}\left\{\frac{(r^2+C^2)}{r^2} - \frac{r^2}{(r^2+C^2)}\right\}. \quad (8)$$

The previous assumption that the axial strain is negligible implies that the axial strain is the mean of the tangential and radial stresses. Then the stress conditions in the cylinder wall are equivalent to a pure shear stress S with a superimposed hydrostatic tension. It is widely accepted that hydrostatic stresses have no effect on the behaviour of a ductile metal[8] and therefore the behaviour of the metal in the cylinder wall will be similar to that of a torsion specimen of the same metal and they will have similar shear stress/strain curves to failure.

If a strain at the bore $\left(\text{i.e., } \frac{u_i}{r_i}\right)$ is now assumed, the increase in radius and the maximum shear strain at any radius may be calculated from equations (7) and (8). The corresponding value of shear stress can be obtained from the shear stress/strain curve for the cylinder material based on torsion tests, and equation (6) may be evaluated by either graphical or arithmetical integration to give the internal pressure. Obviously, to deduce the complete pressure/expansion curve by assuming numerous values for the bore strain, and then finding the internal pressure in each case, would be excessively tedious. Manning has, however, suggested a method by which the pressure/expansion curve for a cylinder of any K can be easily determined from a single tabulation involving only one arithmetical integration. The ultimate pressure can be readily obtained from the pressure/expansion curve, and from pressure/expansion curves for several cylinders of different K an ultimate pressure/K curve can be constructed.

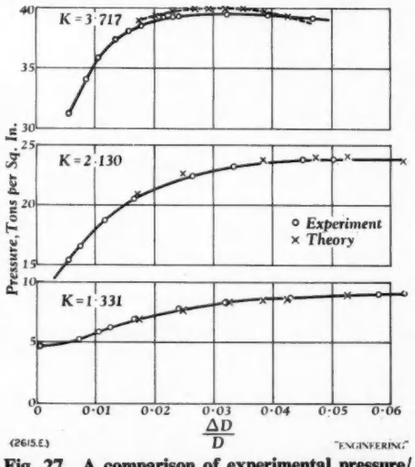

Fig. 27 A comparison of experimental pressure/expansion curves with the values predicted by Manning's theory, showing the close agreement.

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IMPROVEMENTS AT SWANSEA DOCKS

B.T.C. Authorise Construction Work

The British Transport Commission have authorised an improvement scheme for shipping at Swansea Docks, South Wales Ports, at an estimated cost of £700,000. It provides for better approach facilities; increased locking capacity; and deeper water in dock for deep-draughted vessels.

The scheme is expected to be completed in about two years. Swansea's trade, which includes a large oil traffic based on the oil refinery at Llandarcy, exceeds 10 million tons a year.

STABILISING SHIPS IN ROLL

EXPERIENCES WITH THE DENNY-BROWN STABILISER

The engineering design and development of the Denny-Brown ship stabiliser were described in a lecture entitled "Experiences in the Stabilisation of Ships," given before the Institution of Engineers and Shipbuilders in Scotland by Sir William Wallace, C.B.E., F.R.S.E., of Brown Brothers and Company, Limited, on Tuesday, January 11. In the first section of the lecture Sir William gave the history of the development of the Denny-Brown stabiliser. We give below an abridged version of the main part of the lecture in which the author describes the engineering development, the troubles encountered, and the adopted modifications to overcome them, concluding with a record of some of the successes. The principle of the Denny-Brown stabiliser, it may be recalled, was fully described in ENGINEERING *in an article on the P. & O. liner "Chusan" in the issue of December 29, 1950, (page 557, vol. 170).*

In the history of the stabiliser, four different types of fin have been evolved, partly a sa result of hydrodynamic research and partly to simplify production and reduce weight. Fig. 1 shows the progress in design of fins actually fitted on ships; all produce approximately the same righting moment.

The original plain plate fins, as fitted to the Isle of Sark in 1936, were simple steel castings. They had an area of 53 sq. ft., a lift coefficient at 20 deg. tilt of 0·6 and a corresponding drag coefficient of 0·28. The fixed-front moving-tail fin had an area of 49 sq. ft., and at 20 deg. tilt the lift and drag coefficients were 0·63 and 0·14 respectively. The first was formed in cast steel, but owing to the severe weight penalty the design was modified for fabricated construction. Some 100-odd installations were built, none of which has given trouble.

The next design used two fins of half the required area, one above the other. With a total area of 41 sq. ft., they gave a lift coefficient of 0·95 and a drag coefficient of 0·22 at 20 deg. tilt. The construction was generally similar to the previous design with formers located by shoulders on the finshaft, welded to suitable stiffeners, the whole being plated over. Although known to reduce the efficiency at the outboard end, a rounded nose was adopted in place of the square end to avoid the possibility of flutter due to eddies.

The flap fin has now become standard equipment on the Denny-Brown stabiliser. As depicted in Fig. 1, the total area of fin and tail flap was 21 sq. ft. With the main fin tilted 20 deg. and the tail flap at 30 deg. to the main fin, it gives a lift coefficient of 1·75 and a drag coefficient of 0·35. Again the construction is similar to that of the previous designs, but with the root-end section of the fin shaft considerably increased to withstand the greater load per unit area.

ASBESTOS-LINED PLASTICS BEARINGS

For lubricating the bronze hinge bearings of the tail flap, the only access was through the finshaft. It was therefore arranged to supply, at suitable intervals, oil from the servo system through the finshaft-extending cylinder. The system, though quite effective, was expensive to make. Hence in the latest installations the tail-flap bushes are made of asbestos-lined plastics, lubricated by sea water, and the shafts are of stainless steel.

In June, 1949, the P. & O. Company agreed to instal a Denny-Brown stabiliser in their new liner Chusan under construction at Barrow.

The righting moment required to stabilise this ship was 6½ times greater than that of any activated-fin stabiliser so far fitted, requiring an area of 78 sq. ft. (25 sq. ft. was the largest previously fitted). The design, manufacture and installation had to be completed in six months.

INSTALLING THE CHUSAN STABILISER

It was decided to cut and reinforce the necessary openings in the hull, and the box housing the fins was designed in two parts, the outboard half to be welded to the ship's hull, the inboard part to be flange-bolted to the inboard half. The hull was sealed again before the ship was launched. During fitting-out, a compartment was built in a space designed as an oil-fuel tank, and the whole stabiliser equipment except the outboard shafts and fins was taken down No. 2 hold, through holes cut in intervening bulkheads, and erected complete. In dry-dock in Liverpool the closing plates on the hull were removed and the fins were bolted to the inboard shaft.

The fin construction generally followed earlier practice, except that each shaft was split into two parts connected by integrally-forged flanges; but the rushed design resulted in a design error aggravated by faulty welding techniques. No trouble was experienced during the extensive trials.

Following on satisfactory reports from the owners of the Chusan, the Cunard company placed a contract in 1950 for installing a stabiliser on their 16,000-ton ship Media. The lower speed of the Media necessitated fins of 98 sq. ft. area per fin. Installation was completed in six weeks—an excellent performance. The fin design followed generally that of the Chusan installation which had been in service 21 months prior to the trials.

FATIGUE THROUGH FAULTY WELDING

All possible trials were carried out satisfactorily on the Media prior to handing over, and the report that she had lost one of her fins in mid-ocean after three days on her first voyage came as a great shock. Examination of the broken fin-shaft, which had fractured where the shell plating of the fin had been welded to the inner part of the radius of the half-coupling, revealed an obvious fatigue failure initiated by a crack developing between the fin-cover plate and the shaft coupling (Fig. 2). The error was the reliance on welding a thin section to a heavy section without issuing a rigid specification for the welding technique. Actually, the operation had resulted in a notch being cut right into the highly stressed part of the outboard finshaft.

The Chusan fin-shafts, of similar design but possibly more carefully welded, operated satisfactorily for 3½ years and were replaced as a precaution by the redesigned outboard shaft and fin, in which the shaft cross-section was increased in depth, all welding in way of maximum stress was eliminated, and all radii were increased to the maximum. To date, the modified fins on the Media have given satisfactory service.

A stabiliser generally similar in design and approximately the same size as those fitted in cross-channel vessels was installed in the French liner Maroc. One of her fins was lost in a storm; it had broken off half-way along the tapered part of the outboard part of the shaft, for which there was no obvious explanation. Both fins were replaced by a fin and shaft forged as one unit.

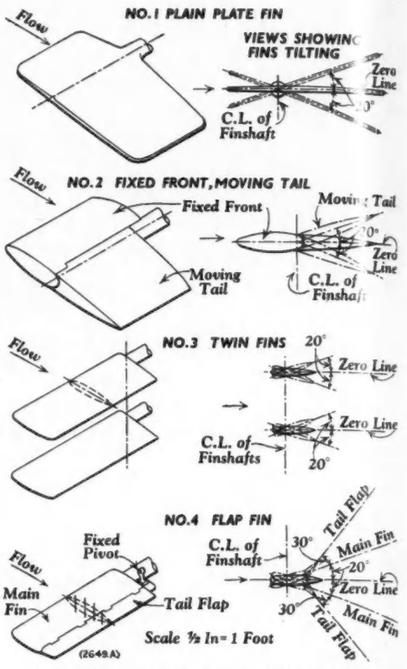

Fig. 1 Progressive designs of stabilising fins.

The next mishap was the loss of one fin off the Bergen steamship Leda. Defective material was suspected, but unfortunately the recovered part of the shaft found its way into the melting shop before tests had been carried out. Until restored to its original condition, the Leda was satisfactorily stabilised with only one fin, indicating that the design was sound.

STRAIN-GAUGE TESTS: FIN-SHAFT MODIFIED

To cut down production hours, it was decided to make a set of fins for the French liner Laos as a steel casting flange-bolted direct to the inboard forged steel fin-shaft. To prove the suitability, load and strain gauge tests were carried out in the works, the actual working load being reproduced as nearly as possible except that the torsion, which is small, was neglected.

The stresses in the fins at half and full load and at 35½ per cent. overload were found to be quite low. Unexpectedly high stresses were

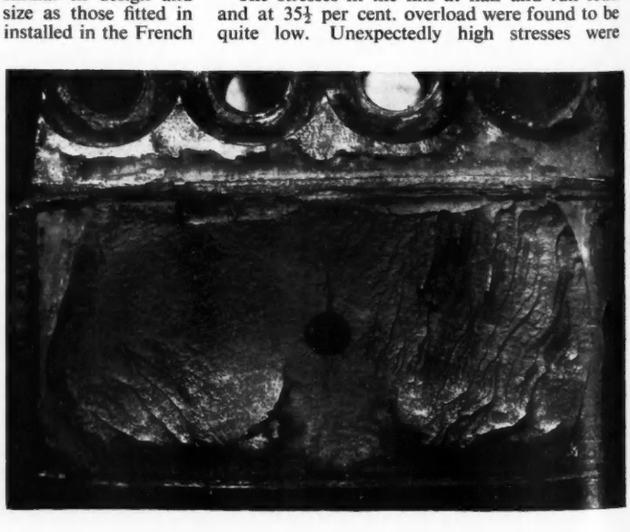

Fig. 2 In welding the shell plating of the fin of the "Media" at the shaft coupling, a notch had been cut right into a highly stressed region resulting in fatigue failure.

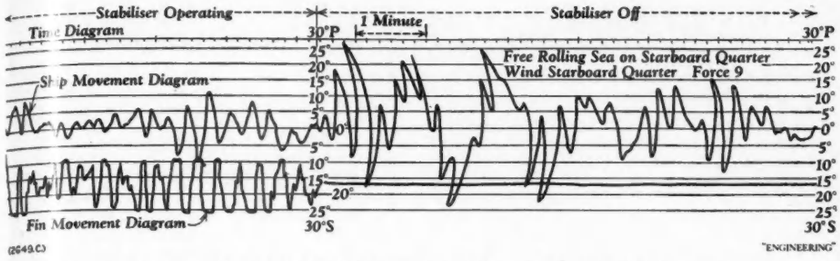

Fig. 3 Roll record of H.M.S. "Pheasant" with and without stabiliser action.

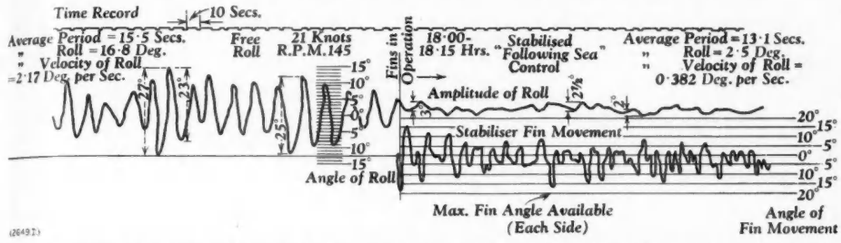

Fig. 4 Roll and fin-angle record of "Leda," rolling freely and then stabilised. The graph clearly shows how little angular movement was required to stabilise the vessel. Other evidence indicates that no increase in shaft horse-power is required for a given speed when a vessel is stabilised.

recorded, however, on the inboard shaft, and as a result of further investigations, particularly in the region of the flange, the fins and shafts were redesigned to eliminate the coupling with its attendant stress raisers. The design adopted was a plain shaft free from all changes of section, attached to the cast-steel fin by tapering the shaft and fitting it into the heart of the fin. A rather fat-looking fin resulted, but tests carried out on models in the cavitation tunnel at Haslar showed that the hydrodynamic characteristics were satisfactory. All new designs for large fins are based on this arrangement, the first of which was installed in the Iberia, in which cast-steel fins weighing 21 tons each were employed. In the future, fins will be fabricated on a cast-steel socket carried on the finshaft; this should cut the weight down to approximately 12 tons.

The stabiliser for the Orient liner Oronsay was partially constructed prior to the mishap on the Media. The outboard fin-shafts were therefore scrapped and shafts similar to the redesigned Media fin were installed. The trials were satisfactory, and on service this ship provided the best record so far available of a stabiliser reducing the roll to a value lower than was thought theoretically possible. Satisfaction was short-lived. On June 16, 1954, after 1,239 hours of satisfactory operation, one fin was lost, and seven days later the other fin was lost due to fatigue failure of the eight shaft-coupling bolts; from the same cause, the Viet-Nam lost one fin after 16 months in service. All ships at sea are now having the coupling bolts replaced with Nitralloy steel nitrided bolts, as the fatigue life of the original bolts in salt water was undoubtedly underestimated. All bolts now fitted are tightened to a predetermined stressed length.

SUCCESSFUL PERFORMANCES

So far, this report records failures in battle with the seas. It is now permissible to turn to the brighter side of the picture. Fig. 3 shows the roll record obtained on H.M.S. Pheasant when, northward bound, she ran into bad weather, with the stabiliser in action, and subsequently when the stabiliser was switched off to enter Milford Haven for shelter.

Fig. 4 shows one of the few records available showing a ship, the Leda, rolling freely and then stabilised, and the angle of fin simultaneously recorded. The record shows how little angular movement was required to stabilise the ship.

The question of fin drag is often raised. Tests carried out by the Admiralty on one of H.M. sloops on the Skelmorlie mile—horse-power maintained constant—gave the following results: 1st run, fins retracted, speed 19·1 knots; 2nd run, fins extended, stationary, no measurable change in speed; 3rd run, fin control gear set to angle fins up and down in unison and timed to ship's period, producing a very slight pitching movement—speed 18·1 knots; 4th run, fins set and operated to force ship to roll, speed 17 knots.

With these results available there was no hesitation in guaranteeing that a stabilised ship would, for the same horse-power, maintain the same speed when stabilised as when rolling freely. Tests by the owners of the Orsova and many other reports confirm this conclusion.

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It is reported that the Cunard liner Queen Elizabeth will be fitted with Denny-Brown stabilisers during her 10-week annual overhaul now taking place in the King George V dry dock at Southampton. Parts of the ship's interior will have to be rearranged to accommodate the stabiliser housing and operating gear. The Queen Elizabeth, the largest vessel to be fitted with stabilisers, will have two fins, about 14 ft. long and 7 ft. wide on both sides of the ship, amidships and forward.

SUPPORTING MINE ROOFS IN BAD ROCK

Dry Drilling for Holding Bolts

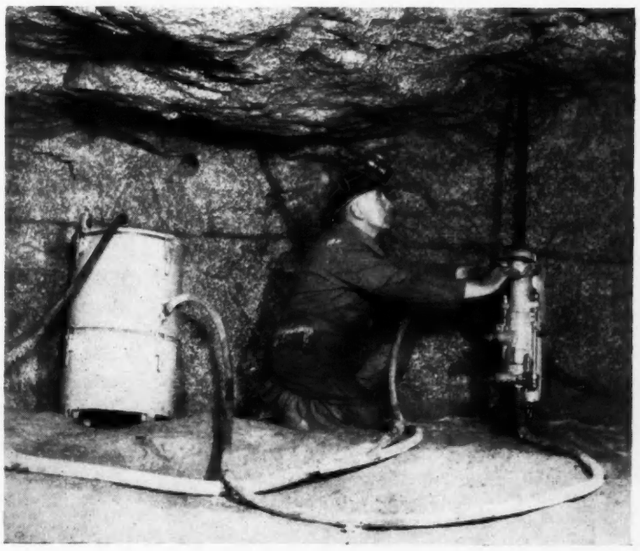
Roof bolting of mines and tunnels through rock deposits involves driving long bolts into the rock which has planes of weakness due to thin bedding, cleating or faulting, to join and reinforce the strata so that they will act as an integrated whole, thereby enabling the roof to span the opening without additional support. The bolts have an expanding point at the leading end which enables the bolts to be fixed into firm rock. The value of the bolts may be enhanced by using them to fix beams or plates to the soffit but, by and large, their use is intended to speed construction by eliminating the need for rib-type sets or other supports. This elimination of sets or beams and columns will effect a saving in their cost as well as in their storage and handling. Rock bolting is not necessarily limited to the roofs of tunnels; the walls and floors may also be strengthened in this way when the rock is unstable.

Further advantages are also to be obtained if a lining has to be built within the tunnel, particularly if a concrete lining is to be used. With arch-rib supports, removal of the lagging and wedges from behind the ribs and scaling loose material can prove a hazardous undertaking whereas, with roof bolting, no further preparatory work is necessary and some overall saving in concrete can generally be obtained.

Roof bolting has been practised by the St. Joseph Lead Company, operating in south-eastern Missouri, U.S.A., for more than 20 years, but it was not until after the end of the war, in 1947, that the practice began to be extensively used in the United States. Reference to its adoption elsewhere than in the United States is extremely meagre.

Recently, however, a demonstration of roof bolting was given at the gypsum mines, of the Plaster Board Company, at Robertsbridge, Sussex, by Holman Brothers, Camborne, Cornwall, using their "Dryductor" system for dustless dry drilling. In this system the dust and chippings created when penetrating the rock are drawn back through a hollow drill steel and out through the rear of the machine into a suitable collector. Typical equipment is illustrated below, where the machine is shown mounted on a stoper leg for roof bolting; inverted, the machine is suitable for floor bolting and, on an airleg, for side-wall bolting.

The drilling machine, of the familiar pneumatic percussive type, differs from usual designs by the large-diameter tube through the centre; this has entailed discarding the normal twist bar,



Roof bolting in progress; bolts, about 4-ft. long, are set into the rock so rendering the roof self-supporting over the width of the opening. Holman "Dryductor" equipment is being used for drilling; with this method, little or no rock dust escapes into the mine atmosphere.

and rotation of the steel is obtained by means of rifle splines on the piston stem engaging with a twist nut and rachet mechanism at the forward end of the cylinder. An anvil block provides a suitable termination for the forward end of the central tube within the machine and, as a result, either collared or uncollared steels can be used. The machine is provided with vents to minimise the risk that air will creep past the piston and interfere with the vacuum; it is also designed so that it cannot release dust while it is drilling and, moreover, unless there is a back suction, it cannot drill.

To assist in dust extraction, and in the maintenance of the necessary vacuum, it is advisable to use a drill steel with a hole diameter of not less than $\frac{3}{8}$-in. It is usual to use cross-bits having four holes in the face, one between each wing, but none in the centre, the holes being of such a size that anything they pass will go through the rest of the system.

There are several ways of collecting the dust, but the usual method is to pass it through a short length of abrasion-resistant hose to a metal container which houses the vacuum-creating " Educator," the filter elements and an ample space in the base for settled drillings. The dust enters at about the mid-point and is deflected downwards so that coarse material settles out of the air stream which then rises to pass through the filters where the fine dust is trapped, allowing clean air to emerge through an outlet at the top.

The casing of the collector comprises three pieces: a ribbed sheet-metal dust container, a similarly-made filter container and a light-alloy cover, the three pieces being held together by toggle clips and kept airtight by large-section rubber sealing rings. The Educator is compressed-air operated and is attached within the filter element to the lower side of the cover so that the filter has only to pass the air which is induced through the hollow drill steel. Each collector is provided with two space dust collectors and lids. This ensures that the one in use may be replaced when full.

The advantages of the " Dryductor " method are: first, the atmosphere is kept free from dust, to the benefit of the operator; second, when drilling wet (to lay the dust) it is essential, prior to placing firing charges, to remove sludge from the hole by means of a blast of compressed air, but with the Dryductor system this is not necessary and the hole can be charged immediately.

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LOADING COILS

Units Cast in Resin for Telephone Cables

The loading coils, which are inserted in telephone cables to maintain the transmission characteristics within acceptable limits, are usually wound on dust-iron cores and are installed in iron pots, which are filled with compound as a protection against moisture. This method of loading, however, lacks flexibility, as the number of coils (which are inaccessible) can only be altered by changing the pots.

Mullard, Limited, Shaftesbury Avenue, London, W.C.2, have therefore designed coils cast in synthetic resin, which fit inside the sleeve used for a normal cable splice or combined loading and jointing unit. These coils are readily accessible and can be added to or removed as may be required. The splice at the loading point is only slightly larger than that of a normal joint, only one being required instead of two, and there is no iron pot or stub end. Moreover, if it is desired to fill the cable with gas under pressure there is a free passage through the loading points.

In manufacturing the new coils improved performance is obtained by the use of Ferroxcube as the magnetic material. The resistance is practically constant over the working frequency range and is low enough at the higher frequencies to be suitable for high quality programme circuits or carrier frequency loading. The coils may be also closely stacked without risk of cross-talk.

MECHANISED HANDLING PLANT

EQUIPMENT DESIGNED FOR THE SMALLER COAL YARD

A complete mechanised handling plant, especially designed for the smaller merchant, has been installed by Charrold Limited, 40 Trinity-square, London, E.C.3, at Coote and Warren's coal wharf at Chelmsford. Allowing for seasonal variation, the plant set up can easily handle 15,000 tons of coal a year (all grades) under the operation of three men, assisted by the lorry drivers. It enables mechanical bagging to be carried out under cover and removes any need for shovelling. A plant for large yards was described in ENGINEERING, vol. 176, page 605 (1953).

The plant at Chelmsford consists of a mobile loader, three large hoppers (8 tons capacity each) with scraper-conveyors and four small hoppers with gravity feed. The loader is a Taylor and Sons " Jumbo " which has a hydraulically-operated grab of $1\frac{1}{2}$ cub. yards capacity and is driven by a Perkins P 4 Diesel engine. It is used to keep the hoppers filled with coal, which is taken directly from railway wagons as far as conditions allow.

The three large hoppers, shown in the illustration below, have sliding doors which allow the contents to fall on to the scraper-conveyors at a rate controlled by the door opening. This gives control of the quantity of coal being carried up to the bagging platform. In addition, one of the hoppers has an electrically-driven vibrating feeder plate which also assists in evening the feed to the conveyor, particularly with some grades of coal. Each conveyor is driven by a 2-h.p. motor controlled by push-button on the bagging platform, with emergency controls near the hopper doors. Part way up the conveyors are screens which allow slack to fall through as the mixed coal passes upwards. The slack can then be removed and sold separately.

At the top of the conveyors, the coal falls between guides into a sack held open by a loader; the bottom of the sack rests on scales. The push-buttons controlling the conveyor motor are by the loader's right hand so that control is quick and simple. The weight in the sack is made exact by adding or throwing back an odd lump or so. The stopping and inching of the conveyor, together with the control of the rate of feed by the adjustment of the hopper door, are sufficiently under control to make it rare that more than a single lump need be moved by hand. The height of the conveyors can be adjusted by the block and tackle which can be seen in the illustration.

In this plant, the conveyors deliver to a bagging platform which is the same height as the floors of the lorries. Therefore, the sacks have only to be carried straight on to the lorries when the latter have backed down to the platform. Most of the platform is under cover, so that not only are shovelling and lifting eliminated but the work can be carried on with some degree of protection against the elements. The lorries can be loaded faster than the Jumbo operater can keep the hoppers filled, but their absence on delivery allows him to catch up. As mentioned earlier, as far as possible, coal will be taken direct from wagons to the hoppers, but there is also a stacking ground where the contents of wagons can be placed if the hoppers are full and the wagon has to be emptied. The stack also acts as a reserve to cover any short breaks in the arrival of supplies.

The four small hoppers stand on the bagging platform and are intended for fuels not in great demand. Sacks are filled from them by gravity, hand control being used of the type described in the article referred to earlier. It is not intended that any hopper should be confined to any one type of coal—the aim is to put into it that type which can be bagged immediately. This calls for some planning in arranging deliveries of coal ordered, but this can be done by the foreman with much saving of time and double journeys. Odd sacks of one grade representing the last of a hopper load can be stored on the platform until required.

All this plant is built up of simple units which can be arranged to suit the layout of any particular site. The number of them required will depend, of course, on the volume to be handled. In the installation, the stacking area should be paved as this aids recovery of the coal by a mechanical loader and also reduces losses. It has been found that the turn-round of wagons has been speeded up, and the bagging system is one which lends itself to piecework rates.

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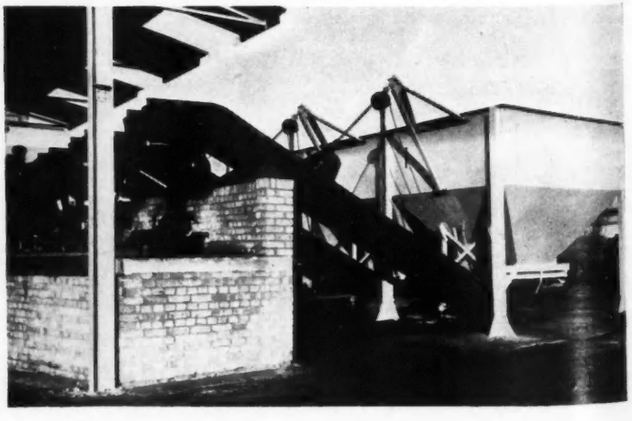
" DEFORMED " PRESTRESSING BARS

Where the length of concrete members has been less than 25 ft., prestressing has not been economical as it was difficult to develop sufficient bond strength along the length of the steel, so making it necessary to leave positive end anchorages permanently in position. To overcome this McCalls Macalloy, Limited, Templeborough, Sheffield, are now making a deformed bar in three nominal sizes, $\frac{1}{2}$ in., $\frac{5}{8}$ in. and $\frac{3}{4}$ in., which can be stressed up to 45 tons per square inch and will develop an adequate bond. To minimise wastage, and to save screwing both ends of the " Macalloy " bar, the company are also making available wedge grip-blocks for use at the " holdfast " while the jack is used at the other end for stressing the bar. Taken together, these two developments of deformed bars and simple wedge anchors (which can be retrieved) make prestressing of shorter concrete members more economical than hitherto.



Coal either from store or direct from wagons is mechanically loaded into the hoppers from which the scraper-conveyors take it to the bagging and weighing platform. Push-button controls enable the sacks to be filled quite accurately—the last lump being added or removed by hand.

A MODERN GREASE PLANT

BIRKENHEAD WORKS OF VACUUM OIL COMPANY

In the summer of 1954 the Vacuum Oil Company, Caxton House, London, S.W.1, brought the new grease plant at their Birkenhead works into full production. The grease plant in use before the war was destroyed, along with much other plant, by enemy action in 1941; a temporary plant was set up in 1941 to produce grease, but it was not possible to start building a new plant until July, 1951. The reconstructed plant incorporates some of the most modern methods and equipment, and production of all types of grease is 10,000 tons a year per shift. The main contractors were Head Wrightson Processes, Limited, 24-26 Baltic-street, London, E.C.1.

A diagrammatic layout of the grease plant is shown in the accompanying illustration. In general terms, greases are soap-thickened lubricating oils; the raw materials needed for grease are therefore lubricating oils and the constituents of soap, fats or fatty acids and an alkali such as lime or caustic soda or some other metallic base. The raw packaged stocks, fats and alkalis, are received and stored in the ground-floor warehouse; they are transferred as required to the top floor by fork-lift trucks and a six-ton capacity lift. The liquid stocks, which include the lubricating oils and fats used for soap bases, are stored in tank farm adjacent to the plant; from there they are pumped through pipelines to the manufacturing floor.

The infra-red heater, shown over the fat melting tanks, is used to free solid fats from the containers in which they are received; previously, the emptying of drums and other containers was a laborious process done partly by hand, but the infra-red heater has speeded production greatly. The constituents of the soap are weighed and fed into the contactor kettles; these are heated to about 550 deg. F. by the hot oil circulating system, and saponification begins. Pressure is generated in the contactor and when the process is completed, in about 20 min., the contents are discharged to one of the two adjacent kettles which it serves. Other components and the necessary amount of mineral oil are stirred into the soap concentration in the kettle until the required standard is achieved; the time taken for this final stage varies according to the product from one to five hours.

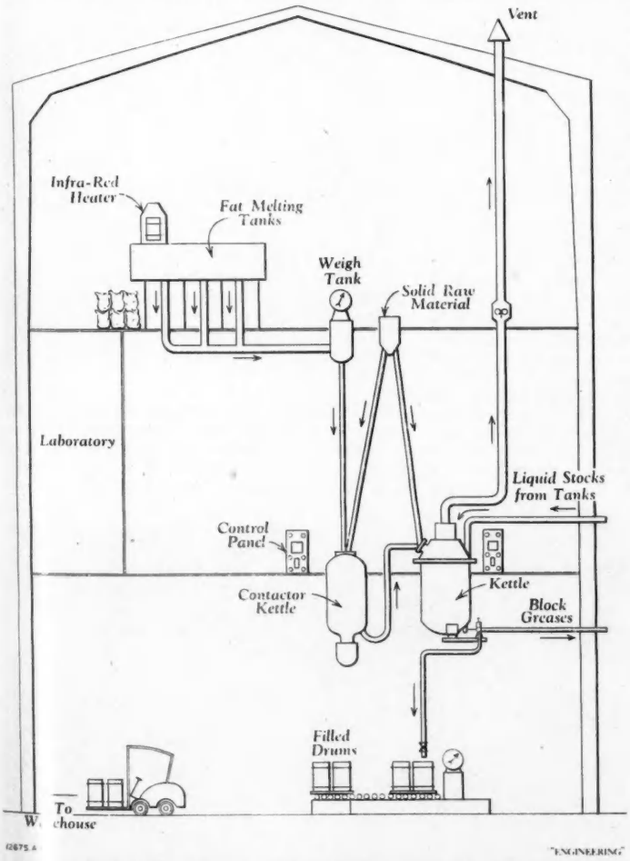
The product is tested during manufacture, and when approval has been given to the batch of grease, the outlet valve at the base of the kettle on the ground floor is opened and the finished grease is pumped through filters into pre-stencilled packages. A Cornell grease homogeniser installed on the ground floor is used to reinforce the mixing in the kettle for some grades of grease. The filled packages are removed by fork-lift truck to a cooling area where they are finally sealed and taken to the warehouse or loading bay.

The chief manufacturing vessels are four contactor heaters, three of 6,000 lb. capacity and one of 3,000 lb., and eight kettles; there are four kettles of 15,000 lb. capacity, three of 8,000 lb. and one of 2,000 lb. The contactors each have a high-speed impeller, driven through the bottom of the vessel, which moves the contents over three heating surfaces, thus ensuring high heating rates. The contactors are heated by Socony-Vacuum heat transfer oil which is circulated through an oil-fired tubular heater at a temperature of about 600 deg. F. Four of the kettles are heated by steam and four by oil. The internal surfaces of the kettles are machined and the contents are mixed by contra-rotating paddles fitted with scrapers to assist heat exchange and prevent local overheating. The contactors and the kettles have ventilating systems which prevent the escape of fumes or odours during manufacture.

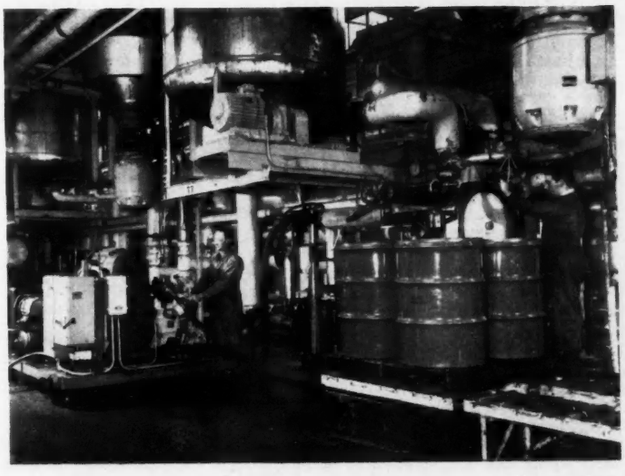
In the manufacture of grease it is important to regulate the times and temperatures of heating, the rate of admission of lubricating oil, and the rate of cooling. In Vacuum Oil's new plant the control, once pre-set, is automatic; each kettle has its own control panel, and the instruments ensure that correct temperature and process time are maintained during manufacture; all liquids from the storage tank farm are controlled by automatic shut-off meters pre-set to the required volume.

The heater for the circulating oil has a capacity of 10 million B.Th.U.s per hour and, as already mentioned, heats the oil to about 600 deg. F.; the contents of the system is 4,500 gal., and the rate of circulation 1,200 gal. per hour.

Research work in greases is done by the Socony-Vacuum Oil Company, Incorporated, in New York, and by Vacuum Oil Company's central laboratories at Wandsworth. The research work in London is followed by trial batch production at Birkenhead in the pilot plant, which consists of a 100-lb. contactor and a 400-lb. kettle. The pilot plant and the laboratory are next to each other on the first floor; routine laboratory tests are carried out on the raw materials, the grease during production, and the final product.



The grease plant is arranged on three floors; raw materials are weighed on the top floor, the manufacturing contactors and kettles are on the first floor, and packages are filled with grease on the ground floor.



The finished grease is pumped into steel barrels on the ground floor. The Cornell homogeniser on the left is used to reinforce the mixing in the kettle for some grades of grease.

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JAMES WATT MEDAL

Awarded to Dr. I. I. Sikorsky

The Council of the Institution of Mechanical Engineers have awarded the 1955 James Watt International Medal to Dr. Igor Ivan Sikorsky, of the United States, in recognition of his life's work in applying science to the progress of mechanical engineering through pioneering development of aircraft of various types.

The James Watt International Medal was founded to commemorate the bi-centenary of the birth of James Watt, which took place on January 19, 1736. It is awarded every two years to an engineer of any nationality who is considered worthy of the highest award the Institution can offer and that a mechanical engineer can receive.

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At the annual dinner of the North East Coast Institution of Engineers and Shipbuilders, held in Newcastle-upon-Tyne on January 21, the Minister of Transport, the Rt. Hon. J. A. Boyd-Carpenter, was the principal guest. The President of the Institution, Mr. P. L. Jones, M.C., B.Sc., Wh.Ex., was in the chair.

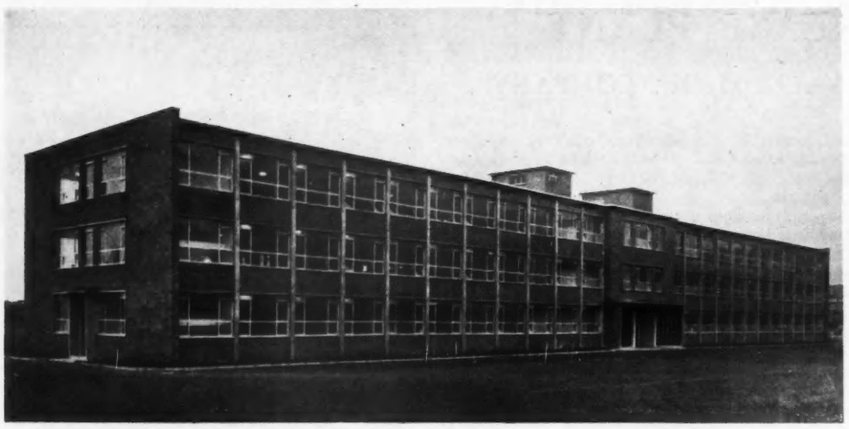

Fig. 1 The new office building of the Plant Department of British Oxygen Engineering Limited has recently been completed and includes drawing-office accommodation.

HIGH-PURITY INDUSTRIAL OXYGEN FROM LIQUID AIR

MODERN LIQUEFACTION AND DISTILLATION PLANT

High-purity oxygen is a commodity with many industrial applications and its preparation in quantity by liquefaction and distillation of air is a process which during the last 50 years has undergone, in accordance with rising demand, considerable expansion and development. Present requirements are such that British Oxygen Engineering, Limited, a subsidiary of the British Oxygen Company, Limited, Bridgewater House, Cleveland-row, St. James's, London, S.W.1, has found it necessary to extend its Plant Department, which deals with the development, design and erection of new equipment. Some of the Department's recent work and the general character and origins of the oxygen separation process are described in this article.

ORIGINS AND APPLICATIONS

The commercial production of oxygen was first undertaken by the Brins Oxygen Company, which started work in 1886, and achieved a steady output three years later. At that time demand for the gas was not large and it was mainly used for limelight illumination. The discovery in 1895 by the French chemist, Le Chatelier, that the combustion together of oxygen and acetylene produced a flame of higher temperature (3,100 deg. C.) than was possible with any other known gas combination revealed new uses for these gases, and the advent of the oxy-acetylene blowpipe with its numerous industrial applications to cutting and welding added immensely to the need for an abundant supply of oxygen. Other applications developed included flame cleaning, a process for scouring corroded steelwork, flame gouging and flame hardening. The introduction of the blowpipe coincided with the development of techniques for separating oxygen from the atmosphere on a large scale.

Since the early years of the century, progress in air-liquefaction processes has been rapid and has led not only to the economic production of oxygen and nitrogen, but also to the extraction of argon and the other rare gases from the atmosphere. Systems for the storage and transport of liquid oxygen were also developed, and after about 1930 a high proportion of the oxygen delivered to industrial users was in this form. Distribution in large works was effected by evaporation of the liquid into appropriate pipelines.

To-day oxygen occupies a prominent position in a wide range of industrial processes; most ferrous and non-ferrous metals can be joined by techniques employing oxygen in conjunction with acetylene or other fuel gases, and the oxygen jet enables steel of almost any thickness to be cut to close tolerances. Oxygen also plays an important part in steel making and for this purpose the large quantities required are measured not in cubic feet but in tons. The use of liquid oxygen as a component of the propellant mixture in certain missiles and aircraft has now become well established and vast developments in this field are envisaged.

To meet these many requirements, it has been necessary to build a variety of separation plants, each producing oxygen for a particular kind of application, and for more than 20 years the British Oxygen Company has been concerned in their design and construction.

MODERN SEPARATION PROCESS

Modern methods of oxygen production involving the distillation of liquid air can best be described with reference to the traditional circuit for separating oxygen of 99·5 per cent. or higher purity. Oxygen comprises approximately 21 per cent. of the atmosphere, the remaining constituents of which are nitrogen (78 per cent.), argon (0·9 per cent.) and other rare gases (0·1 per cent.). To obtain oxygen for commercial use the most satisfactory procedure is large-scale distillation. Plants built for this purpose incorporate tubular heat exchangers and double-column units, the upper and lower parts of which are separated by multi-tube condensers.

In the liquefaction process, the main operation is to reduce the temperature of the air to a low value, and this is achieved by compression of the gas, heat removal by transfer and finally re-expansion to the original pressure. The expansion takes place either through a throttle valve or in a machine such as an expansion engine or a low-temperature turbine.

The subsequent distillation process, which takes place in a rectification column such as that shown on the right in Fig. 2, is made possible by the difference in boiling points between oxygen and nitrogen; oxygen boils at −183 deg. C. and nitrogen at −196 deg. C. A typical plant erected at Wembley for the production of high-purity oxygen at a rate of approximately 45 tons a day is illustrated in Figs. 2 and 3.

In the foreground of Fig. 2 can be seen the air compressor, which can handle over 4,000 cub. ft. of free air per minute and provides the compressed fluid for liquefaction and distillation, carried out in the section of the plant shown more clearly in Fig. 3. As is evident, the plant is well equipped with instruments and requires a very small number of operators.

The contents of the main unit or " cold box " in Fig. 3 are similar in general character to the items illustrated in Fig. 4, which shows the lower section of a double-column distillation unit and on its left a large tubular heat exchanger for lowering the temperature of the compressed air to liquefaction point.

TRANSPORT AND STORAGE OF OXYGEN IN LIQUID FORM

Oxygen is much more economically stored and handled as a liquid than as a gas, and the problem involved is that of maintaining it at a temperature lower than −183 deg. C., above which it would evaporate. Transport, too, is much facilitated when carried out with the oxygen in liquid condition; a modern insulated liquid-oxygen transport tanker (Fig. 5), for example, can convey a load of 7½ tons, which would otherwise, as compressed gas, fill over 800 normal-size cylinders. The weight of these cylinders would be approximately 70 tons. A storage tank holding 75 tons of liquid oxygen is equivalent to a gasholder of 2 million cub. ft. capacity; Fig. 5 also shows a liquid-oxygen storage vessel of 2 million cub. ft. equivalent gas capacity.

Liquid oxygen is supplied primarily to those users who take the gas in sufficient quantity to prohibit its carriage in cylinders, and these include steelmakers, who employ it for refining steel and treating the metal during rolling processes. However, there are still many cases in which it is more convenient to use cylinders, and on outdoor sites and in smaller factories they continue to provide an important service. Oxygen cylinders, when charged to their normal pressure of 1,980 lb. per square inch, have an equivalent capacity of 180 or 240 cub. ft. in the standard sizes and thus can provide an adequate supply

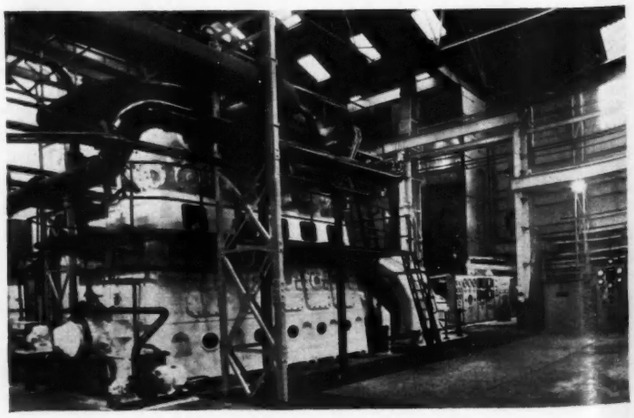

Fig. 2 The large-scale production of oxygen is carried out by distillation of liquid air and this picture shows a 250,000 cub. ft. per hour free-air capacity compressor employed in the initial liquefaction process. In the rear can be seen other associated plant.

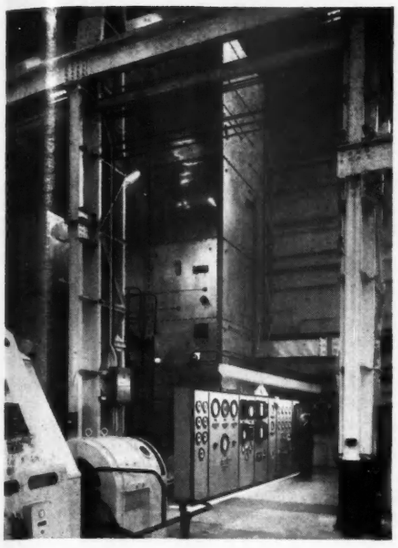

Fig. 3 Instrument panel and "cold box" for the liquefaction and distillation process, which yields oxygen of 99·5 per cent. or greater purity.

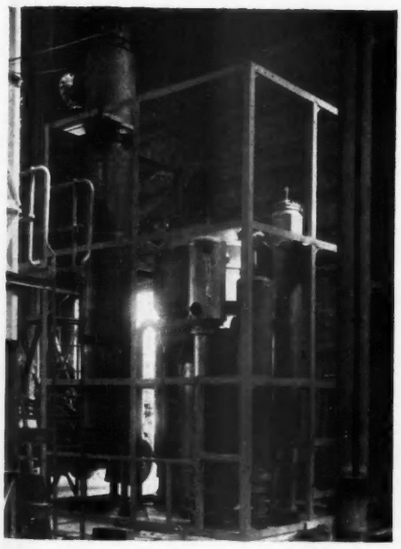

Fig. 4 Contents of "cold box" including lower section of a double-column distillation unit and on the left a tubular heat exchanger.

of gas for the majority of welding and cutting operations.

BRITISH OXYGEN ENGINEERING, LIMITED

The complex nature of the processes and the plant involved in oxygen production has entailed the constant introduction of new methods and techniques in order to ensure the highest possible efficiency of operation, and for the last decade the British Oxygen Company has maintained a large research and development department with that object. The work of this department has been to provide fundamental data on physical properties and phase equilibria of gases, construction materials and insulation, and to investigate new methods of production and their economic aspects. Other departments have dealt with the development and design of separation and handling equipment and with the fabrication and erection of plants.

A few years ago the branch of the company concerned with plant manufacture was reorganised and established as a subsidiary known as British Oxygen Engineering, Limited. Recently, the departments of the parent company enumerated above have also been incorporated in the engineering organisation, and all these functions are now combined in the work of the plant department of that concern under one director.

To accommodate the large staff entailed by these developments, extensive new offices have been erected on the Edmonton site of British Oxygen Engineering, Limited, and the building, which includes drawing offices, is shown in Fig. 1.

(*Editorial comment in Weekly Survey*)

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ELECTRICITY SUPPLY METERS

Under-registration at Low Loads

In a paper read before the Supply Section of the Institution of Electrical Engineers on April 28, 1953, Mr. L. B. S. Golds and Mr. P. Schiller pointed out that the tendency of electricity supply meters to give under-registrations at low loads make it impossible to determine the optimum period after which they should be removed for cleaning and recalibration without information about the proportion of consumption at various loads.* The paper also presented the results of tests made on 110 domestic consumers' installations in the Northmet Sub-Area of the Eastern Electricity Board, in which a meter registering on separate dials the consumptions below 10 per cent., between 10 and 25 per cent., between 25 per cent. and 100 per cent., and over 100 per cent. of the current rating was used; these readings were then compared with that on the consumer's meter.

* *Proceedings of the Institution of Electrical Engineers*, vol. 100, Part II, page 619 (1953).

This area was not, however, considered very representative and further tests have therefore been carried out in the Blackburn Area of the North Western Electricity Board, the results of which are now given below.

EFFECT OF METER RATING

The average annual consumption of the Blackburn consumers sampled was 1,230 kWh, compared with 1,050 kWh in the district as a whole, and 1,330 kWh for all of the domestic consumers in the country. The corresponding figure for the Northmet consumers was 2,250 kWh, so that the Blackburn test may be regarded as more representative. Of the meters tested in Blackburn, 48 per cent. were rated at 10 amperes and 37 per cent. at 25 amperes, the remainder being of the 20-ampere rating. On the other hand, in the Northmet area, 33 per cent. of the meters were rated 5 amperes, another 33 per cent. at 20 amperes, and 22 per cent. at 10 amperes, the remaining 12 per cent. being rated at 25 amperes or more. These figures had a great effect on the results of the tests since, although the average annual consumption in Blackburn was lower than that in the Northmet area, the rating of the smallest meter was higher. The highest installed load in Blackburn was 65 amperes, compared with 80 amperes in the Northmet area, but in neither case did the demand exceed 40 amperes.

Tests showed that in Blackburn 25 per cent. of the consumption was taken when the load did not exceed 10 per cent. of the meter rating. This compared with only 13 per cent. in the case of the Northmet area, a result due to the fact that no 5-ampere meters were installed in the latter case. In each of the meter ratings 23 per cent. of the consumption was measured below 10 per cent. of full load. This is important since tests of meters on site showed the average under-registration was nearly 3 per cent. at a 5 per cent. load.

The results in these two areas are being supplemented by others, and it is hoped that upon the completion of these additional tests it will be possible to draw conclusions which will be of assistance to meter manufacturers and the electricity supply industry.

* * *

CONTRACTS

International Television Link. The British Broadcasting Corporation, London, W.1, have placed an order with the POST OFFICE for a permanent two-way television link between London and the Continent. This will replace some of the temporary equipment which has been used for experimental programme exchanges and is a step towards making such exchanges a regular feature in the programmes of European television services. The first section of the permanent link, which it is hoped will be ready for use before the end of this year, will consist of coaxial cables between London and St. Margaret's Bay. The next section will consist of a two-way radio link across the English Channel to be operated in conjunction with the French Postes, Télégraphie, Téléphone (P.T.T.). This section will take some three years to complete, but in the meantime, the permanent coaxial cables will be temporarily extended from St. Margaret's Bay to Swingate, near Dover, where the B.B.C. and Radiodiffusion et Télévision Françaises will provide and operate a temporary two-way cross-channel radio link between Swingate and Cassel in Northern France.

Iron-Ore Handling Plant. An order for a 500-ton per hour capacity ore-handling plant for the stockyard of Colvilles Ltd., Clyde Iron Works, Glasgow, has been received by the FRASER AND CHALMERS ENGINEERING WORKS, Erith, Kent, of the General Electric Co. Ltd. The plant includes two conveyors, one 950 ft. and the other 700 ft. in length, and screens, motors and control gear.

Railway Wagons. The British Transport Commission have placed contracts for 24-ton hopper ballast wagons with the METROPOLITAN-CAMMELL CARRIAGE AND WAGON CO. LTD., Saltley, Birmingham (398 wagons), and CHARLES ROBERTS & CO., LTD., Horbury Junction, near Wakefield (399 wagons).

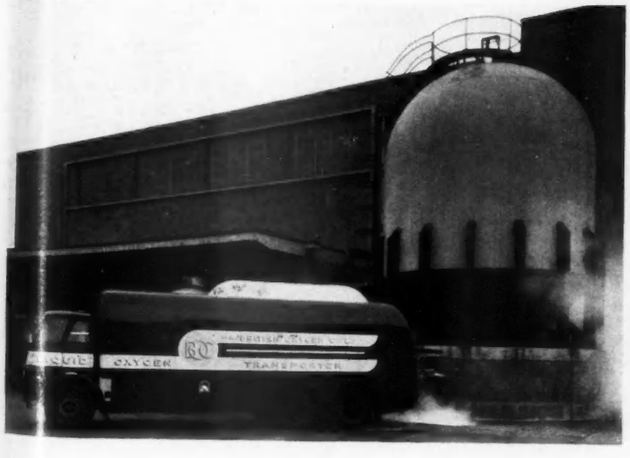

Fig. 5 Transport tanker for carrying oxygen in liquid form. 7½ tons of oxygen, which as gas would occupy 800 cylinders, can be conveyed in one vehicle. To the right can be seen a liquid-oxygen storage vessel of 2 million cub. ft. equivalent gas capacity.

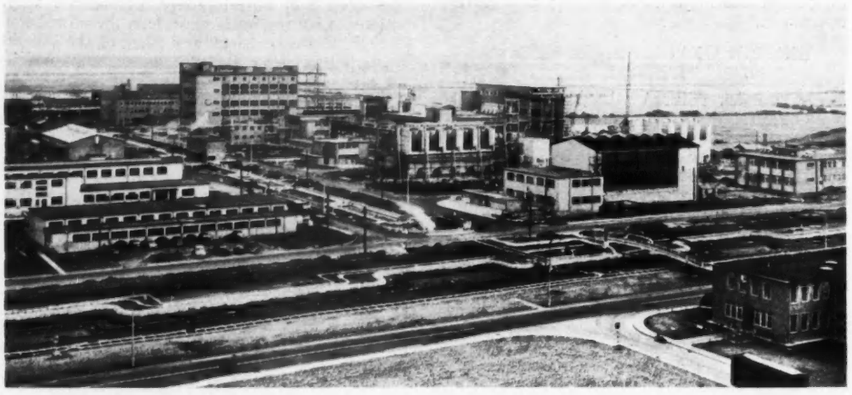

Fig. 1 The Terylene plant covers 30 acres. In the tallest building the polymerisation is carried out; the building behind houses the spinning plant. Towards the front are the recovery plant and the first stages of the process.

SYNTHETIC FIBRE PRODUCTION

TERYLENE PLANT BEGINS OPERATION AT WILTON

The synthetic fibre now known as Terylene was discovered by Mr. J. R. Whinfield and Dr. J. T. Dickson of the research laboratory of the Calico Printers Association at Accrington. The discovery was made in 1941, and in 1943 Imperial Chemical Industries Limited agreed to help in its development. Later, in 1947, I.C.I. were granted world rights for its production (except in the United States of America, where they had already been granted to du Pont de Nemours and Company) and recently licences have been granted for production of the fibre in Canada, Italy, France, Western Germany and the Netherlands.

Terylene is a mineral oil product in that it is made from xylene and ethylene—obtained from the cracking of petroleum. In the synthesising, para-xylene is first converted to terephthalic acid by reaction with nitric acid and then to dimethylterephthalate by methanol. In the next stage ethylene glycol and a catalyst are added to give di-hydroxyethyl terephthalate which is polymerised in an autoclave to form polyethylene terephthalate or Terylene. This is then melted and extruded as filaments which are spun into yarn or cut into staple.

The plant that is being built at Wilton, Yorkshire—to which extensions have been started although the original is not yet complete—adjoins other I.C.I. plants already on that site, and is connected to the Billingham site by pipelines. Thus the raw materials required are easily accessible. Production has been begun, using materials supplied from the pilot plant at Huddersfield. The capacity of the first unit will be 11,000,000 lb. per annum, and that of the second which should be completed this year, will be the same; the current production from the pilot plant at Huddersfield and its spinning plant at Hillhouse is approximately 2,000,000 lb. per annum. The output will be equally divided between filament yarn and staple fibre. Fig. 1 shows the Wilton plant with the extensions being added on the right of the buildings. The process flow is from the right foreground to the left rear.

PRODUCTION OF THE POLYMER

Ethylene, from which the ethylene glycol used in the process is made, is supplied from the olefine plant, which also supplies other plants at Wilton. From the oil-cracker in this plant come also the mixed xylenes from which para-xylene is concentrated. The methanol is pumped across from the Billingham plant. In the first section of the Terylene plant, shown in Fig. 2, partly under construction, the reaction between para-xylene and nitric acid takes place forming the white crystals of terephthalic acid.

The second building houses the plant in which this acid is processed with methanol to give the dimethyl terephthalate, a substance which can be purified to the degree required to give a consistent fibre at the end. At the conclusion of the process, the output goes to a recovery plant where any unused reagents and carriers are extracted for re-use.

The production of the polymer is carried out in the third building—the tallest of those shown in Fig. 1. The isomer is first produced by an ester exchange process in heated vessels and flows to the autoclaves on the floor below. Some of these are shown in Fig. 3. Polymerisation is carried out in them at a high temperature and a high vacuum. Mechanical stirrers are fitted. Conditions are instrumentally controlled rendering the process largely automatic. When each batch has been polymerised it is extruded through a slit into the casting machines below, where it is solidified as a wide ribbon.

Each casting machine, two of which are shown in Fig. 4, serves two autoclaves. The ribbon of molten Terylene falls on to a revolving drum and is solidified in water. For ease of handling, the ribbon passes into a cutting machine in which it is sliced into chips about 4 mm. square and 2 mm. thick. This chipper forms the left-hand part of the casting machine in Fig. 4. The chips so formed fall into movable hoppers on the floor below, which are moved by electric trucks, and the amounts weighed before being placed in the main mixing and storage hoppers. An air lift is used for this and also to convey the chips across to the spinning building.

FILAMENT YARN

In the spinning building, which can be seen on the extreme left of Fig. 1, the chips are first dried in horizontal rotary drums, using a stream of hot air. They then pass into hoppers which run on overhead rails and are discharged through seals into the melting pots. When molten, the Terylene is pumped continuously through the extrusion plates, known as spinnerets, each having in it a number of fine holes arranged in a circle. The emerging filaments harden in the air and each group is wound on to a cylinder as undrawn yarn. Before going on to the cylinder, the filaments pass over a wheel dipping into an emulsion the object of which is to lubricate the yarn for subsequent processes and to prevent the generation of static electricity.

The filled cylinders are hung on frameworks which stand on wheeled trolleys. This simplifies movement into the adjoining inspection room where the undrawn yarn is subjected to tests. When it has been passed, the frames are hung on an overhead conveyor to take them to the drawing machines. Among the checks imposed at this stage is one for size—carried out by weighing a known length wound on to a special frame. The inspection room is in communication with other parts of the plant so that any fault can be notified immediately to the section concerned.

The next stage in the production of the filament yarn, which can be handled and woven

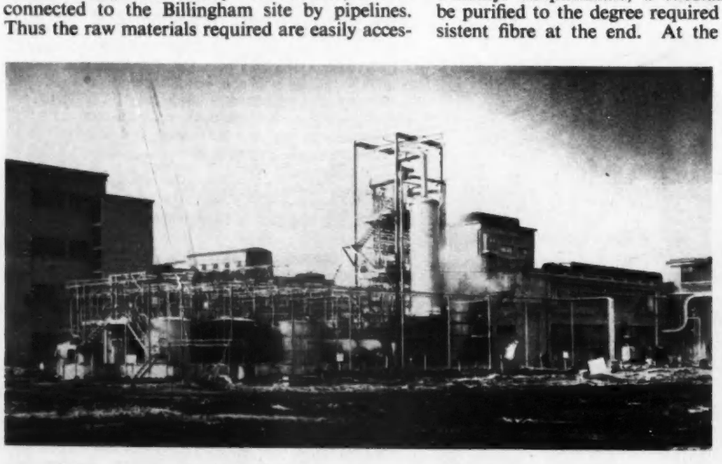

Fig. 2 The first stage is the production of terephthalic acid from para xylene and nitric acid. The complete process is continuous and flow lines throughout the plant have been arranged for this.

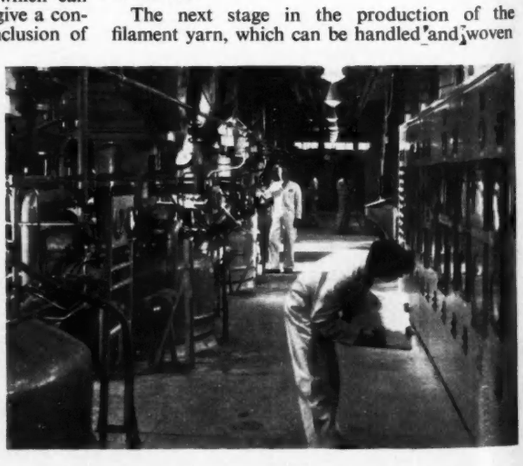

Fig. 3 Polymerisation is carried out in autoclaves at high temperature and high vacuum. Conditions are mainly instrument controlled.

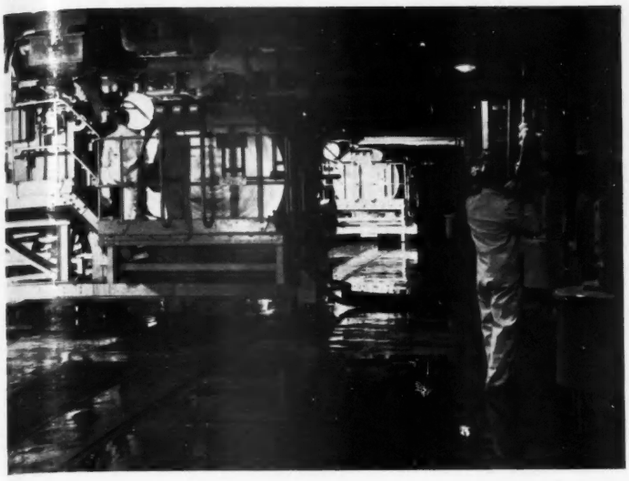

Fig. 4 The molten polymer is solidified in casting machines and then cut into chips for ease of handling. The chips are dried, melted and extruded as filaments for spinning.

in much the same way as silk, is to increase its strength by drawing it out to several times its original length, giving at the same time a slight twist to the fibres. This is done while the yarn is being heated which sets the twist. The drawing machines are fed by the overhead conveyor on which are hung the frameworks carrying the coils of undrawn yarn. The drawn yarn is wound on to waisted bobbins and is afterwards tested for physical properties and inspected for such blemishes as finger marks, oil splashes or bruises.

Some manufacturing processes require that the fibres should have a greater degree of twist than that imparted to them during the drawing operation. In this country, this is usually done by the textile firms themselves, but yarn for export is twisted or " thrown " at Wilton. It is unwound from the waisted bobbins and rewound on to tubes in such a way that the fibres are given twists of from 5 to 9 turns per inch, according to the denier of the yarn. This twist has to be heat-set and this is carried out in ovens. Owing to shrinkage during the setting, it is desirable to use collapsible tubes for the winding. After setting, the yarn is wound on to cones.

STAPLE FIBRE

The production of staple fibre, which can be handled in much the same way as wool, is identical to that of filament yarn up to the spinning process. Here the first difference arises, as the filaments for staple fibre are extruded in groups of larger numbers than for filament yarn, and the groups, instead of being separately wound on bobbins, are all passed together through guide tubes and are stored in large metal tanks. A mechanism causes the final guide tube to move over the area of the tank so that the undrawn " tow " is laid evenly and can be withdrawn without tangling. Tow from about 20 of these tanks (and consisting, therefore, of several thousand filaments) is simultaneously fed to the drawing machine for a stretching process similar to that applied to the filament yarn. After drawing, the fibres are crimped and set in this form by heat. The continuous tow is then cut into staple lengths which can be varied as required. The cut fibres are baled and removed on a roller conveyor for weighing and dispatch.

The sections that make up the spinning building have barrel-vaulted roofs and have the walls lined with sound-absorbent material. They are air conditioned, as also is the polymer building. Leading directly from the spinning building is the warehouse accommodation, also barrel-vaulted, where the packages awaiting shipment are handled by fork-lift trucks. At present only two deniers are being made at Wilton—50 and 75—but later the range will be extended to include 100, 125, 150 and 250 denier. The finish can be either bright or dull.

The production process is essentially a continuous one and the plant will therefore operate 24 hours a day. For this reason, only men will be employed. It is expected that some local miners and quarrymen, who will become available as the local quarries are exhausted, will be absorbed in the 800 required for operating and maintaining the first unit—a number which will be considerably increased when the second plant comes into production. Throughout the plant, mechanisation has been incorporated to make the run of the work smooth and speedy, and to reduce manhandling.

A small quantity of Terylene made at the pilot plants has now been on the market as clothing for some time. Its main advantages are its resistance to wear and abrasion and the fact that it will not crease. Pleats can be heat-set during manufacture and will not be lost during normal washing of the garment. It is also moth-proof and shrink-proof and only deteriorates very slowly in sunlight. As the harmful part of the spectrum is in the ultra-violet, house curtains protected by glass are not affected. It is also immune from rotting or biological attack.

The same advantages apply when Terylene is used for industrial purposes. Additional properties are: resistance to acids and oxidising agents; high mechanical strength (123,000 lb. per square inch tensile); low moisture absorption; and good electrical insulation. For these reasons, Terylene is being used for fishing nets, ropes and lines, for filtration cloths and dyeing bags and for canvases, coverings and reinforcement for fire hoses. As electrical insulation, it is being used in motor armatures and its electrical properties are maintained up to a temperature of 180 deg. C. As production from the Wilton plant increases, and the fibre becomes more generally available, there is little doubt that its range of uses will be increased.

(*Editorial comment in Weekly Survey*)

The Electrothermal " Bunsen " is a heating apparatus for use in laboratories, and combines the advantages of a gas burner with the cleanliness in operation and ease of control associated with electrical heating.

★ ★ ★

LABORATORY-VESSEL HEATER

Small Electrical Apparatus

An unusual heating apparatus specially suitable for laboratories, even where a gas supply is normally available, has been introduced by Electrothermal Engineering Limited, 270 Neville-road, London, E.7. Known as the Electrothermal " Bunsen," it is said to combine the advantages of the gas burner with the cleanliness in operation and ease of control associated with electric heating, and can be used for most of the routine work in a laboratory generally carried out with the aid of a gas burner.

Since the radiation from the heater is directed upwards only, it can be used for such purposes as heating test tubes (in about 10 seconds), crucibles, small flasks and beakers, irrespective of their shape. By using it inverted, it can also provide the heat source for evaporation processes.

The unit is made of corrosion-resistant metal and consists of a specially formed replaceable heating element mounted in the top of a vertical tube, which forms the supporting case. This tube, as can be seen from the illustration, is provided with air-circulation holes in the lower part, and a concentric gap between the heating element and the casing prevents any undue temperature rise. The heating element is made of a nickel-chromium wire embedded in a refractory aluminium-oxide casing.

The conical working cavity is formed in such a way that radiant heat is directed towards and concentrated in the cavity centre—the position occupied by the lower part of the test tube when the heater is in use. The heater is provided with rubber feet to protect the bench, and a removable cowl 3¾ in. in diameter fitted at the top of the apparatus is designed to deflect heat radiation from the hand holding the test tube. If necessary, the unit can be comfortably held by the operator during heating.

The power loading of the apparatus is 300 watts, and the controlled temperature of the element ranges from 1,380 deg. F. to 1,832 deg. F. The overall height of the unit is 6¾ in. and the diameter of its base 4¾ in. It can be arranged to operate on voltages of either 110-130 or 200-250.

The Electrothermal Bunsen is easily controllable, not subject to heat losses by reflection, free from fumes, unaffected by draught and silent. A " Micro Bunsen " is also made.

★ ★ ★

In the article " Tubular Vibrator Conveyors," in our issue of January 14, page 53, the capacity of the conveyor was omitted due to a printing error. This figure should have been 35 tons per hour, and the conveyor is operated by 2·2-kW motors.

FORTHCOMING EXHIBITIONS AND CONFERENCES

This list appears in the last issue of each month. An asterisk(*) indicates events appearing in the list for the first time. Particulars of forthcoming exhibitions and conferences not included below may have appeared in ENGINEERING, *December* 31, *page* 870. *Organisers are invited to send to the Editor particulars of forthcoming events as soon as arrangements are made.*

BUSINESS EFFICIENCY EXHIBITION.—Tues., Feb. 8, to Fri., Feb. 11, at the Granby Hall, Leicester. Organised by the Office Appliance and Business Equipment Trades Association, 11-13 Dowgate-hill, London, E.C.4. Tel. CENtral 7771.

AGRICULTURAL MACHINERY AND EQUIPMENT EXHIBITION (INTERNATIONAL).—Sun., Feb. 13, to Sun., Feb. 20, at the Palais du Centenaire, Brussels. Organised by the Société de Mécanique et d'Industries Agricoles S.A., 29 Rue de Spa, Brussels.

HARDWARE TRADES FAIR.—Mon., Feb. 14, to Fri., Feb. 18, at the Royal Horticultural Society's Halls, Vincent-square, London, S.W.1. Organised by Universal Exhibitions Ltd., 74 Holland Park, London, W.11. Tel. PARk 7360.

NICE INTERNATIONAL FAIR.—Sat., Feb. 26, to Mon., Mar. 14. Inquiries to the secretary, Foire de Nice, 5 Rue Hotel de Ville, Nice.

LEIPZIG INTERNATIONAL FAIR.—Spring Fair : Sun., Feb. 27, to Wed., Mar. 9. Autumn Fair : Sun., Sept. 4, to Fri., Sept. 9. *Agents:* Willoughby, Young and Hayes, 127 Oxford-street, London, W.1. Tel. GERrard 0357.

STATIONERY AND BOOK TRADES FAIR.—Mon., Feb. 28, to Fri., Mar. 4, at the Royal Horticultural Society's New Hall, Greycoat-street, London, S.W.1. Organised by National Newsagent Ltd., 149 Fleet-street, London, E.C.4. Tel. CITy 2604.

AGRICULTURAL MACHINERY EXPOSITION (INTERNATIONAL).—Tues., Mar. 1, to Sun., Mar. 6, at the Parc des Expositions, Porte de Versailles, Paris. Organised by the Union des Exposants de Machines et d'Outillage Agricoles, 95 Rue St. Lazare, Paris, 9e. *Agent:* Mr. R. C. Liebman, 178 Fleet-street, London, E.C.4. Tel. CITy 5889.

AIR POLLUTION CONGRESS (FIRST INTERNATIONAL).—Tues. and Wed., Mar. 1 and 2, at the Hotel Statler, New York. Organised by the Society of Mechanical Engineers, 29 West 39th-street, New York, U.S.A. See ENGINEERING, November 26, 1954, page 682.

IDEAL HOME EXHIBITION.—Tues., Mar. 1, to Sat., Mar. 26, at Olympia, London, W.14. Organised by Associated Newspapers, Ltd., New Carmelite House, London, E.C.4. Tel. CENtral 6000.

FRANKFURT INTERNATIONAL TRADE FAIR.—Sun., Mar. 6, to Thurs., Mar. 10. *Agents:* L.E.P. Transport, Ltd., Sunlight Wharf, Upper Thames-street, London, E.C.4. Tel. CENtral 5050.

COLOGNE INTERNATIONAL SPRING FAIR.—Household Goods and Hardware: Sun., Mar. 6, to Tues., Mar. 8. Textiles and Clothing: Sun., Mar. 13, to Tues., Mar. 15. *Agent:* Mr. Neven du Mont, 123 Pall Mall, London, S.W.1. Tel. WHItehall 8211.

*CORROSION ENGINEERS, NATIONAL ASSOCIATION OF.—Annual Conference: Mon., Mar. 7, to Fri., Mar. 11, at Chicago. Apply to the National Association of Corrosion Engineers, Southern Standard Building, Houston 2, Texas, U.S.A.

VIENNA INTERNATIONAL SPRING FAIR (36TH).—Sun., Mar. 13, to Sun., Mar. 20. *Agents:* The British Austrian Chamber of Commerce, 29 Dorset-square, London, N.W.1. Tel. PADdington 7646.

ASTE WESTERN INDUSTRIAL EXPOSITION.—Mon., Mar. 14, to Fri., Mar. 18, at Los Angeles, California. Organised by the American Society of Tool Engineers, 10700 Puritan-avenue, Detroit 38, Michigan, U.S.A.

(A.S.E.E.) ELECTRICAL ENGINEERS' EXHIBITION.—Tues., Mar. 15, to Sat., Mar. 19, at Earl's Court, London, S.W.5. Sponsored by the Association of Supervising Electrical Engineers, 23 Bloomsbury-square, London, W.C.1. Apply to Mr. P. A. Thorogood, Electrical Engineers (A.S.E.E.) Exhibition, Ltd., 23 Bloomsbury-square, London, W.C.1. Tel. MUSeum 3450.

*CHEMICAL ENGINEERS' FUNCTIONS AND EDUCATION, CONFERENCE ON.—Mon., Mar. 21, to Wed., Mar. 23, at Church House, Dean's Yard, London, S.W.1. Organised by the Institution of Chemical Engineers, 56 Victoria-street, London, S.W.1. Tel. VICtoria 6161. See ENGINEERING, October 15, 1954, page 512.

*IRON AND STEEL ENGINEERS, ASSOCIATION OF (AMERICAN).—*Western Meeting:* Mon., Mar. 21, to Wed., Mar. 23, at San Francisco. *Spring Conference:* Mon., April 25, to Wed., April 27, at Detroit. *Annual Convention:* Mon., Sept. 26, to Thurs., Sept. 29, at Chicago. Apply to Association of Iron and Steel Engineers, Empire Building, Pittsburg 22, Pa., U.S.A.

*RADIO ENGINEERING SHOW.—Mon., Mar. 21, to Thurs., Mar. 24, at Kingsbridge Amory, New York. Apply to William C. Copp, Institute of Radio Engineers, 1475 Broadway, New York 36.

UTRECHT INTERNATIONAL SPRING FAIR.—Tues., Mar. 22, to Thurs., Mar. 31. *Agent:* Mr. W. Friedoff, 10 Gloucester-place, London, W.1. Tel. WELbeck 9971.

COPENHAGEN INTERNATIONAL FAIR (9TH).—Fri., Mar. 25, to Sun, April 3, Technical Section. Fri., April 15, to Sun., April 24, Commercial Section. Organised by Dansk Udstillings Syndikat A/S, Forums Anneks Julius, Thomsens Plads, Copenhagen K, Denmark.

FACTORY EQUIPMENT EXHIBITION (THIRD).—Mon., Mar. 28, to Sat., April 2, at Earl's Court, London, S.W.5. Apply to Mr. J. E. Holdsworth, 117 Kingsway, London, W.C.2. Tel. CHAncery 2318.

PROTECTION OF STRUCTURAL STEEL.—Thurs., Mar. 31, and Fri., April 1, at the Institution of Civil Engineers, Great George-street, London, S.W.1. Symposium organised by the Corrosion Group of the Society of Chemical Industry. Communications to Mr. S. C. Britton, Tin Research Institute, Fraser-road, Perivale, Middlesex. Tel. Perivale 4254. See ENGINEERING, November 26, 1954, page 682.

*BOUNDARY LAYER EFFECTS IN AERODYNAMICS.—Thurs., Mar. 31, and Fri., April 1, at Teddington. Apply to the Director, National Physical Laboratory, Teddington, Middlesex.

MILAN INTERNATIONAL SAMPLES FAIR.—Tues., April 12, to Wed., April 27. *Agent:* Dr. V. Schiazzano, 652 Grand Buildings, Trafalgar-square, London, W.C.2. Tel. WHItehall 5521.

LYONS INTERNATIONAL TRADE FAIR.—Sat., April 16, to Mon., April 25. *Agents:* Robert Brandon and Partners, Ltd., 47 Albemarle-street, London, W.1. Tel. HYDe Park 0901.

SWISS INDUSTRIES FAIR.—Sat., April 16, to Tues., April 26, at Basle, Switzerland. Apply to the Swiss Legation, 18 Montague-place, Bryanston-square, London, W.1. Tel. PADdington 0701.

*AMERICAN SOCIETY OF MECHANICAL ENGINEERS.—*Diamond Jubilee, Spring Meeting:* Mon., April 18, to Thurs., April 21, at Baltimore. *Instruments and Regulators Conference:* Mon. and Tues., April 25 and 26, at Ann Arbor, Mich. Apply to the American Society of Mechanical Engineers, 29 West 39th-street, New York 18.

LIÉGE INTERNATIONAL TRADE FAIR.—Sat., April 23, to Sun., May 8, at Liége. Organised by the Foire Internationale de Liége, 17 Boulevard d'Avroy, Liége, Belgium. *Agents:* Mattis Industries, Ltd., 252 Abbey House, Victoria-street, London, S.W.1. Tel. ABBey 7571.

BRUSSELS INTERNATIONAL TRADE FAIR.—Sat., April 23, to Sun., May 8, at the Palais du Centenaire, Brussels. Apply to the organisers at that address.

PHYSICAL SOCIETY'S EXHIBITION OF SCIENTIFIC INSTRUMENTS AND APPARATUS (39TH).—Mon., April 25, to Thurs., April 28, at the Royal Horticultural Hall, Vincent-square, London, S.W.1. Organised by the Physical Society, 1 Lowther-gardens, South Kensington, London, S.W.7. Tel. KENsington 0048. See ENGINEERING, November 5, 1954, page 595.

BRITISH INDUSTRIES FAIR.—Mon., May 2, to Fri., May 13, at Olympia, London, W.14; and Castle Bromwich, Birmingham. Particulars from British Industries Fair Ltd., Ingersoll House, 9 Kingsway, London, W.C.2. Tel. COVent Garden 1461; or from the general manager, British Industries Fair, 95 New-street, Birmingham, 2. Tel. Midland 5021.

*ELECTRIC HEATING CONFERENCE.—Tues. and Wed., May 10 and 11, at Chicago, Ill., U.S.A. Apply to American Institute of Electrical Engineers, 33 West 39th-street, New York 18.

ACHEMA XI GERMAN CHEMICAL APPARATUS CONGRESS AND EXHIBITION.—Sat., May 14, to Sun., May 22, at Frankfurt-on-Main. Organised by DECHEMA Deutsche Gesellschaft für chemisches Apparatewesen, Rheingau-Allee 25, Frankfurt-on-Main.

NEW YORK TRADE FAIR.—Sun., May 15, to Thurs., May 19, at the Armory, 25th-street, Manhattan, New York. Organised by International Trade Shows, 545 Fifth-avenue, New York.

INTERNAL COMBUSTION ENGINE CONGRESS, INTERNATIONAL.—"COLLOQUY 1955—THE HAGUE."—Mon., May 23, to Sat., May 28, at Scheveningen, Holland. Organised by the Congrès International des Moteurs à Combustion Interne, 11 Avenue Hoche, Paris, 8e. Inquiries in Britain may be sent to the secretary of the British National Committee, c/o The British Internal Combustion Engine Manufacturers' Association, 6 Grafton-street, London, W.1. Tel. HYDe Park 5107. See ENGINEERING, September 24, 1954, page 389.

MEDITERRANEAN FAIR (TENTH).—Wed., May 25, to Fri., June 10, at Palermo. Organised by Fiera del Mediterrano, Piazza Generale Cascino, Palermo, Italy.

PADUA INTERNATIONAL FAIR AND PACKAGING SALON.—Sun., May 29, to Mon., June 13, at Padua. Organised by Fiera di Padova, 59 Via N. Tommaseo, Padua, Italy.

LARGE DAMS (FIFTH CONGRESS OF THE INTERNATIONAL COMMISSION).—To open on Tues., May 31, and to be held in Paris. Apply to the British National Committee, 201–202 Grand Buildings, Trafalgar-square, London, W.C.2. Tel. WHItehall 3966. See ENGINEERING, April 2, 1954, page 448; and October 22, 1954, page 520.

BATH AND WEST AGRICULTURAL SHOW.—Wed., June 1, to Sat., June 4, at Launceston, Cornwall. Organised by the Bath and West and Southern Counties Society, 3 Pierrepont-street, Bath. Tel. Bath 3010.

BRITISH PLASTICS EXHIBITION.—Wed., June 1, to Sat., June 11, at Olympia, London, W.14. Organised by "British Plastics" Dorset House, Stamford-street, London, S.E.1. Tel. WATerloo 3333.

BUSINESS EFFICIENCY EXHIBITION.—Mon., June 6, to Thurs., June 16, at Olympia, London, W.14. Organised by the Office Appliance and Business Equipment Trades Association, 11-13 Dowgate-hill, London, E.C.4. Tel. CENtral 7771.

CONFERENCE ON COMBUSTION.—Wed., Thurs. and Fri., June 15, 16 and 17, at Cambridge, Mass., U.S.A. Organised by the American Society of Mechanical Engineers, 29 West 39th-street, New York, 18; and Tues., Wed. and Thurs., Oct. 25, 26 and 27, in London. Organised by the Institution of Mechanical Engineers, 1 Birdcage-walk, St. James's Park, London, S.W.1. Tel. WHItehall 7476. See ENGINEERING, September 24, 1954, page 398.

CONFERENCE ON AUTOMATIC FACTORIES.—Thurs., June 16, to Sun., June 19, at Margate. Organised by the Institution of Production Engineers, 10 Chesterfield-street, London, W.1. Tel. GROsvenor 5254. See ENGINEERING, November 26, 1954, page 683.

*MACHINE TOOL EXHIBITION.—Mon., July 4, to Sat., July 9, at Sydney. Apply to the Sydney Chamber of Commerce, 36 Grosvenor-street, Sydney.

PRINTING, MACHINERY AND ALLIED TRADES EXHIBITION (IPEX).—Tues., July 5, to Sat., July 16, at Olympia, London, W.14. Promoted by the Association of British Manufacturers of Printers' Machinery (Proprietary) Ltd., Clifford's Inn, London, E.C.4. Organisers: F. W. Bridges and Sons, Ltd., Grand Buildings, Trafalgar-square, London, W.C.2. Tel. WHItehall 0568.

*AUTOMOTIVE ENGINEERS, SOCIETY OF.—*West Coast Meeting:* Mon., Aug. 15, to Wed., Aug. 17, at Portland, Oregon. *Aircraft Production Forum and Aircraft Engineering Display:* Tues., Oct. 11, to Sat., Oct. 15, at Los Angeles. *Transportation Meeting:* Mon., Oct. 31, to Wed., Nov. 2, at St. Louis, Miss. *Diesel Engine Meeting:* Wed., Nov. 2, to Fri., Nov. 4. Apply to the Society of Automotive Engineers, 29 West 39th-street, New York 18.

*MATHEMATICAL COLLOQUIUM, BRITISH.—Tues., Sept. 6, to Thurs., Sept. 8, at Exeter. Apply to Secretary, 7th British Mathematical Colloquium, University College of the South-West of England, Exeter. Tel. Exeter 4141.

*LESS COMMON METALS, SYMPOSIUM ON.—Thurs. and Fri., Sept. 22 and 23, in London. Organised by the Institution of Mining and Metallurgy, Salisbury House, Finsbury-circus, London, E.C.2. Tel. MONarch 2096.

Labour Notes

MINERS' WAGES

Some indication of the great progress which has been made in connection with proposed improvements in miners' wages was given at a meeting of local officials of the National Union of Mineworkers at Doncaster last Saturday.

Mr. W. E. Jones, the union's President, told the men's representatives that, as a result of discussions between the National Coal Board and the union, job designations, covering all the varied categories of work performed by day-wage men at every colliery in Great Britain, had been reduced from over 6,000 to about 350.

The union's national executive committee is due to meet again next Thursday and it is confidently expected that delegates from the committee will begin discussions with the National Coal Board in the near future on the introduction of revised wage rates for these 350 new groups.

The union is looking forward to the introduction of an entirely new wage structure for all miners employed at day-wage rates, as a result of these negotiations.

About a thousand of the more highly-paid coal-face miners in Derbyshire have been awarded an increase of 2*s.* 6*d.* a shift, as from January 1 last. The men, who are engaged on power-loading and continuous-mining work, have been earning as much as £3 a shift for some time past.

ABOLITION OF WAGES COUNCIL

Sir Walter Monckton, the Minister of Labour and National Service, has decided to take the necessary steps for the abolition of the Rubber Reclamation Wages Council for Great Britain. The Council was established in 1939 under the provisions of the Trade Boards Acts 1909 to 1918, as a trade board for the rubber reclamation industry, and automatically became a Wages Council on the coming into force of the Wages Councils Act 1945.

Much headway has been made in recent years in the way of organisation, as well as in the standards of remuneration and conditions of employment, in the industry. In these circumstances, the Rubber Reclamation National Joint Industrial Council, which was set up in 1946, recently suggested to the Minister that, as the great majority of employees in the industry now had their wages and conditions of work regulated by the Joint Industrial Council, the Wages Council served no useful purpose and should be abolished.

The Minister has given full consideration to this claim in coming to his decision. In an announcement on the subject, he expresses his pleasure at being able to take the required measures for bringing about the replacement of statutory machinery by a voluntary body established by employers' and workpeople's organisations in the industry concerned.

NEW STRIKES BY STEEL ERECTORS

As a protest against the coming into force of a ban on the working of overtime, a number of fresh strikes in various parts of the country were commenced during the past week-end by men engaged in the erection of steel building frames.

The greatest number of withdrawals of labour took place at Margam steelworks in South Wales, where about 30 steel erectors ceased work. The men's union, the Constructional Engineering Union, withdrew twelve members at Bristol, who were engaged on erection work for Lewis's store. Other sites at which strikes took place were the Sheffield works of Firth-Vickers Stainless Steels Limited, and the Sheffield works of Brown Bayley Steels Limited. In the former case, four men were concerned and, in the latter, eight men. A small number of firms in the Tees-side area were also affected, where a total of 31 men ceased work.

The ban was introduced by the Engineering and Allied Employers' National Federation in an attempt to curb the series of scattered strikes of steel erectors which have been taking place during the past twelve weeks.

A statement issued by the union's general secretary, Mr. Jack Stanley, declared that there was no undue perturbation regarding the employers' ban on overtime and that any employers who might try to get some of the union's members to work overtime would receive but little encouragement.

As stated in these columns last week, the union is seeking parity in wage rates with those paid to craftsmen in the building industry and last summer presented a claim to the employers' Federation for increases of 3½*d.* an hour for men employed in the London area and of 2¾*d.* an hour for those engaged elsewhere.

LIGHTERMEN'S WAGE AGREEMENTS

Difficulties respecting a claim by the Watermen, Lightermen, Tugmen and Bargemen's Union for higher bonus payments led the union, last Friday, to give three weeks' notice to terminate its current wage agreements with the port employers.

Originally, the bonus was payable to lightermen only in cases where they were employed on a ship in which other dock employees were working at piece rates. Lately, however, the bonus has been granted in a variety of other circumstances. The lightermen's complaint is that their employers have offered them an increase in the bonus of only 1½*d.* a day, compared with their claim for a rise of 2*s.* 6*d.* a day.

It is understood from a statement issued by the Lighterage Joint Committee that the notice to end the wage agreements is not to be taken as a notice to withdraw the men's labour, and that negotiations between the two sides to the dispute are proceeding normally. At the same time, the negotiations have evidently reached a delicate stage, as the termination of existing wage agreements without the acceptance of new ones would make it difficult to prevent a stoppage. A further meeting of the Lighterage Joint Committee was due to be held last Tuesday.

In the London area, about 4,000 members of the union are involved in the dispute.

ENGINEERING WAGE CLAIMS

Warnings of the possible consequences of embarking on long-drawn out discussions on the recent wage claims in the engineering and shipbuilding industries were given to leaders of trade unions in these industries at a conference of engineering shop stewards at Manchester last Saturday.

The claims were presented by the Confederation of Shipbuilding and Engineering Unions in mid-December last year. In addition to demands for increases of 15*s.* a week on the basic rates of skilled men and of 10*s.* a week on those of unskilled employees, the Confederation asked the engineering employers to accept the principle of re-grading semi-skilled workers, to agree to the abolition of certain penalty clauses in the industry's holidays agreement, and to consent to payment for summer holidays being based on average earnings.

The shop stewards, who are stated to represent about 120,000 engineering employees in Manchester and the surrounding area, passed a resolution promising full support for the wage demands. They also requested that, if necessary, their executive committee should use " the full strength of the trade unions " to obtain the whole of the Confederation's demands.

It was also decided at the conference that meetings at factory gates should be held wherever possible to present details of the case for wage increases to rank-and-file employees.

The claims for both the engineering and shipbuilding industries are at present under consideration by the employers' Federations and their replies are expected early next month.

FOUNDRY WORKERS' VIEWS

Reference at some length to these claims is made in *The Foundry Workers Journal* for January. In a leading article in the journal, which is the official organ of the Amalgamated Union of Foundry Workers, Mr. J. Gardner, the union's general secretary, states that eight months have elapsed since the settlement of April 13, 1954, which conceded wage increases of 8*s.* 6*d.*, 7*s.* 6*d.* and 6*s.* 6*d.* a week to skilled, semi-skilled and unskilled employees, respectively, in the engineering and shipbuilding industries.

Mr. Gardner points out that the fact that the unions affiliated to the Confederation of Shipbuilding and Engineering Unions immediately thereafter decided to apply for a further increase, which was approved at the Confederation's annual conference, is expressive of the profound dissatisfaction caused by the agreement.

He affirms that the increases obtained last April did not even restore the standard rate for moulders to the level it had in 1947. Price increases since April have caused a further deterioration in the standard rate, expressed in terms of real wages, so that the new claim is more than justified.

A number of statistics, compiled from various sources, are quoted by Mr. Gardner in support of his contentions. Based on price increases since June, 1947, he states, the Confederation's claims would do very little more than restore the minimum standard rate for skilled men at that time. For example, the national minimum rate for moulders in June, 1947, was £5 6*s.* 8½*d.* Add 45 per cent., the equivalent of the increase shown by the interim index of retail prices, and the corresponding austerity rate for November, 1954, would be £7 14*s.* 6½*d.*, whereas, he points out, the actual minimum standard rate is £7 9*s.* 6½*d.*

ENGINEERING STAFFS' CLAIMS

Joint claims by all the unions catering for office employees in the engineering industry, for a minimum of three weeks' holiday with pay after 12 months' service, were rejected by the Engineering and Allied Employers' National Federation on January 20. It is estimated that there are more than 400,000 workpeople in this category in the employ of firms affiliated to the employers' Federation.

A claim by the Clerical and Administrative Workers' Union for the introduction of minimum wages for clerical employees, rising from £7 2*s.* 6*d.* at the age of 22, to £8 5*s.* at the age of 25, was also refused, on the ground that increases could be granted individually to deserving employees. Existing wage agreements in the industry provide for the payment of a minimum rate of £6 15*s.* a week at the age of 21.

The Association of Engineering and Shipbuilding Draughtsmen presented a claim to the employers' Federation for a number of increases for draughtsmen in the younger age groups, and the Federation promised to give careful consideration to these proposals. The increases suggested ranged from an extra 15*s.* a week at 21 to an extra £1 a week at 25, with increases of 15*s.* a week for women aged 19 and above.

NOTICES OF MEETINGS

Association of Supervising Electrical Engineers

LONDON
Discussion on "Lifts." South-East London Branch. Congregational Church, Court-road, Eltham. Tues., Feb. 1, 8 p.m.
"We Will Go to Mars," by R. Lennox Napier. West London Branch. 134 King-street, Hammersmith. Tues., Feb. 1, 7.30 p.m.
"Diesel Engines," by R. W. S. Mitchell. North London Branch. 677 Green Lanes, Harringay, N.4. Wed., Feb. 2, 7.45 p.m.
BOURNEMOUTH
"Electricity Without Tears," by F. G. Hart; and "Industrial Heating Applications," by R. J. Webb. Bournemouth Branch. Grand Hotel, Bournemouth. Mon., Jan. 31, 8.15 p.m.
CROYDON
"Atomic Energy," by Dr. A. Hughes. South London Branch. Café Royal, North End, Croydon. Thurs., Feb. 3, 8 p.m.
LIVERPOOL
"Electronics in Industry," by A. Williams. Liverpool Branch. 9 The Temple, 24 Dale-street, Liverpool. Fri., Feb. 4, 7.30 p.m.
PRESTON
"Electronic Equipment in Industry," by C. J. Teece. Preston Branch. 49A Fishergate, Preston. Wed., Feb. 2, 7.30 p.m.

British Institution of Radio Engineers

LIVERPOOL
"Colour Television: Prospects and Problems in the United Kingdom," by D. W. Heightman. Merseyside Section. College of Technology, Byrom-street, Liverpool, 3. Thurs., Feb. 3, 7 p.m.
MANCHESTER
"Recent Developments in Test Gear in the Radio, Television and Radar Fields," by A. G. Wray. North-Western Section. College of Technology, Sackville-street, Manchester. Thurs., Feb. 3, 7 p.m.

Chemical Society

LONDON
Various original papers. Thurs., Feb. 3, 7.30 p.m.
BIRMINGHAM
"Recent Applications of the Study of Photochemistry to the Study of Reactions," by Professor R. G. W. Norrish. Birmingham Branch. Chemistry Department, The University, Birmingham. Fri., Feb. 4, 4.30 p.m.
SOUTHAMPTON
"Recent Investigations in the Field of Vinyl Polymerisation," by Dr. C. H. Bamford. Southampton Branch. Chemistry Department, The University, Southampton. Fri., Feb. 4, 5 p.m.
SWANSEA
"Adsorption of Vapours by Solids," by Professor D. H. Everett. South Wales Branch. University College of Swansea, Swansea. Fri., Feb. 4, 5.30 p.m.

Engineers' Guild

LONDON
Film Evening. Metropolitan Branch. Caxton Hall, Westminster, S.W.1. Thurs., Feb. 3, 6 p.m.

Illuminating Engineering Society

CARDIFF
"Outdoor Illuminations," by H. Carpenter. Cardiff Centre. Offices of the South Wales Electricity Board, The Hayes, Cardiff. Thurs., Feb. 3, 5.45 p.m.
EDINBURGH
"Studies in Interior Lighting," by J. M. Waldram. Edinburgh Centre. 12 Rothesay-place, Edinburgh, 3. Wed., Feb. 2, 7 p.m.
GLASGOW
"Studies in Interior Lighting," by J. M. Waldram. Glasgow Centre. 39 Elmbank-crescent, Glasgow, C.2. Thurs., Feb. 3, 7.30 p.m.
HULL
"Prescribing for Seeing," by M. L. Berson. Leeds Centre. Offices of the Yorkshire Electricity Board, Ferensway, Hull. Mon., Jan. 31, 7.30 p.m.
NEWCASTLE-UPON-TYNE
"Lighting for Ships," by T. Catten. Newcastle Centre. Roadway House, 8 Oxford-street, Newcastle-upon-Tyne. Wed., Feb. 2, 6.15 p.m.

Incorporated Plant Engineers

LONDON
Debate on the invention of the internal-combustion engine. London Branch. Royal Society of Arts, John Adam-street, W.C.2. Tues., Feb. 1, 7 p.m.
LEEDS
Discussion on "Reclamation of Worn Parts: Metal Spraying." West and East Yorkshire Branch. The University, Leeds. Mon., Jan. 31, 7.30 p.m.
LEICESTER
Discussion on "Fire Prevention and Fire-Fighting in Industry." Leicester Branch. College of Art and Technology, The Newarkes, Leicester. Wed., Feb. 2, 6.30 p.m.
PETERBOROUGH
"Overhead Cranes," by S. W. Heywood. Peterborough Branch. Campbell Hotel, Bridge-street, Peterborough. Thurs., Feb. 3, 7.30 p.m.
SOUTHAMPTON
"The Scope of the Works Engineer," by D. Holland. Southampton Branch. Polygon Hotel, Southampton. Wed., Feb. 2, 7.30 p.m.

Institute of Fuel

LONDON
Adjourned Discussion on Beaver Report on "Air Pollution." Institution of Civil Engineers, Great George-street, S.W.1. Wed., Feb. 2, 5.30 p.m.
DERBY
"Methane Production," by Dr. F. J. Dent. East Midland Section. Joint meeting with the Derby Society of Engineers. Derby Electricity Showrooms, Derby. Thurs., February 3, 7.15 p.m.

Institute of Marine Engineers

LIVERPOOL
"Metallurgy in Marine Engineering," by Dr. J. E. Garside. Merseyside and North-Western Section. Old Swan Technical College, Liverpool. Mon., Jan. 31, 7 p.m.

Institute of Metals

LONDON
"Tin and Tinplate," by Dr. W. E. Hoare. London Local Section. Thurs., Feb. 3, 6.30 p.m.
BIRMINGHAM
"The Effect of Trace Elements on the Properties of Iron and Steel," by Dr. N. P. Allen. Birmingham Local Section. James Watt Memorial Institute, Great Charles-street, Birmingham. Thurs., Feb. 3, 6.30 p.m.
OXFORD
"Deformation of Metals at High Rates of Strain," by Professor A. H. Cottrell. Oxford Local Section. Cadena Café, Cornmarket-street, Oxford. Tues., Feb. 1, 7 p.m.

Institute of Road Transport Engineers

COLCHESTER
"Fuel Consumption," by W. T. Skinner. Eastern Centre. Albert Hotel, Colchester. Wed., Feb. 2, 7 p.m.

Institute of Welding

LONDON
"Electric Welding in a Large Shipbuilding Yard," by R. J. W. Rudkin. North London Branch. Manson House, Portland-place, W.1. Thurs., Feb. 3, 7.30 p.m.
MANCHESTER
"Application of Welding in Power Stations," by M. P. Henzell. Manchester Branch. College of Technology, Manchester. Wed., Feb. 2, 7.15 p.m.
MIDDLESBROUGH
"Welding at Atomic Projects," by I. H. Hogg. North-Eastern (Tees-Side) Branch. Cleveland Scientific and Technical Institution, Corporation-road, Middlesbrough. Thurs., Feb. 3, 7.30 p.m.
NEWCASTLE-UPON-TYNE
"Researches into the Metallurgy of Welding at King's College," by R. N. Parkins and R. F. Tylecote. North-Eastern (Tyneside) Branch. Neville Hall, Westgate-road, Newcastle-upon-Tyne. Thurs., Feb. 3, 7 p.m.
PORTSMOUTH
"Copper Welding Development," by L. Bernhardt. Portsmouth Branch. College of Technology, Portsmouth. Thurs., Feb. 3, 7 p.m.
SWANSEA
"Welding Metallurgy," by H. O'Neill. South Wales Branch. Thurs., Feb. 3, 7.15 p.m.

Institution of Civil Engineers

LONDON
"The Design and Construction of No. 8 Dry Dock at North Shields for Smith's Dock Co., Ltd," by T. F. Burns. Maritime Engineering Division. Tues., Feb. 1, 5.30 p.m.

Institution of Electrical Engineers

LONDON
"Electrical and Magnetic Measurements in an Electrical-Engineering Factory," by D. Edmundson; and "Current Summations with Current Transformers," by A. Hobson. Measurements Section. Tues., Feb. 1, 5.30 p.m.
Address on "The Generation of Electricity in Britain," by the President of the Institution, J. Eccles. London Students' Section. Wed., Feb. 2, 6.30 p.m.
"A Criterion of Distribution Cost," by D. J. Bolton. Thurs., Feb. 3, 5.30 p.m.
LEEDS
"Modern Developments in Atomic Energy," by Dr. T. E. Allibone. North Midland Centre. Offices of the Yorkshire Electricity Division, 1 Whitehall-road, Leeds. Tues., Feb. 1, 6.30 p.m.
MANCHESTER
"A Transatlantic Telephone Cable," by Dr. M. J. Kelly, Sir W. Gordon Radley, G. W. Gilman and R. J. Halsey, North-Western Centre. Engineers' Club, Albert-square, Manchester. Tues., Feb. 1, 6.15 p.m.
PORTSMOUTH
"Breaking of Alternator-Current Circuits," by Commander (L) E. W. Goodman. Southern Centre. Portsmouth College of Technology, Portsmouth. Wed., Feb. 2, 6.30 p.m.
WORKINGTON
"Design, Performance and Application of Miniature Circuit-Breakers," by H. W. Wolff and T. G. F. Atherton. North-Eastern Centre. Workington Technical College, Workington. Fri., Feb. 4, 7 p.m.

Institution of Heating and Ventilating Engineers

LEICESTER
"Heating Engineers' Electrical Installations," by P. Moore. East Midlands Branch. Bell Hotel, Leicester. Wed., Feb. 2, 6.30 p.m.
LIVERPOOL
"New Light on Gravity Circulation," by T. H. F. Holman. Liverpool Branch. Radiant House, Bold-street, Liverpool. Tues., Feb. 1, 6.30 p.m.

Institution of Mechanical Engineers

LONDON
Discussion on "Utilisation of By-Product Heat from High-Pressure Generating Plants." Steam Group Wed., Feb. 2, 6.45 p.m.
CARDIFF
Thomas Lowe Gray Lecture on "Some Factors in the Selection of Machinery for Cargo Liners," by Commander (E) L. Baker, R.N. (retd.). South Wales Branch. South Wales Institute of Engineers, Park-place, Cardiff. Tues., Feb. 1, 6 p.m.
DERBY
"Rocket Propulsion," by Professor A. D. Baxter. Joint meeting of East Midlands Branch and Derby A.D. Centre. Rolls-Royce Welfare Hall, Nightingale-road, Derby. Mon., Jan. 31, 7 p.m.
OXFORD
"Some Aspects of Aircraft Design," by A. Newall. Eastern Branch. Forum Restaurant, Oxford. Thurs., Feb. 3, 7.30 p.m.

Institution of Production Engineers

BASINGSTOKE
"Production Engineering Research," by Dr. D. F. Galloway. Reading Section. Canteen, Transport Equipment, Ltd., Worting-road, Basingstoke. Thurs., Feb. 3, 7.30 p.m.
CAMBORNE
"British Clock and Watch Production," by A. W. Marshall. Cornwall Section. Camborne School of Mines, Camborne. Wed., Feb. 2, 7.15 p.m.
CARDIFF
"Business Visit to Moscow," by Lord Verulam. South Wales Section. South Wales Institute of Engineers, Park-place, Cardiff. Mon., Feb. 7, 7 p.m.
HUDDERSFIELD
"Productivity in Worm Gear Unit Manufacture," by F. J. Everest. Halifax Section. George Hotel, Huddersfield. Tues., Feb. 1, 7 p.m.
LEEDS
"Developments in the Forging Industry," by R. C. Taylor, Yorkshire Graduate Section. Great Northern Hotel, Leeds. Sat., Feb. 5, 2.30 p.m.
MANCHESTER
"Powder Metallurgy," by Dr. E. M Trent Manchester Graduate Section. College of Technology, Manchester. Tues., Feb. 1, 7.15 p.m.
NOTTINGHAM
"The Measurement and Significance of Surface Finish," by R. E. Reason. Nottingham Section. Victoria Station Hotel, Nottingham. Wed., Feb. 2, 7 p.m.
WOLVERHAMPTON
"Economics in Production Engineering," by Dr. F. A. Wells. Wolverhampton Section. Wolverhampton and Staffordshire Technical College, Wulfruna-street, Wolverhampton. Wolverhampton Section. Wed., Feb. 2, 7.15 p.m.

Institution of Structural Engineers

BIRMINGHAM
"The Use of Light Alloys in Structures," by H. V. Hill. Midland Counties Graduates' and Students' Section. Joint meeting with the Birmingham and Five Counties Architectural Association. James Watt Memorial Institute, Great Charles-street, Birmingham. Mon., Jan. 31, 6 p.m.
CARDIFF
"Simple Plas.ic Theory," by Dr. B. G. Neal. Wales and Monmouthshire Branch. South Wales Institute of Engineers, Park-place, Cardiff. Mon., Jan. 31, 6.30 p.m.

Junior Institution of Engineers

LONDON
Film Evening. Fri., Feb. 4, 7 p.m.
BIRMINGHAM
"Josiah Wedgwood, Potter," by T. Lyth. Midland Section. James Watt Memorial Institute, Great Charles-street, Birmingham. Wed., Feb. 2, 7 p.m.

Manchester Association of Engineers

MANCHESTER
"Problems Associated with the Selection of Machine Tools for Heavy Engineering Production," by J. Henderson. Engineers' Club, Albert-square, Manchester. Fri., Feb. 4, 6.45 p.m.

Reinforced Concrete Association

BIRMINGHAM
"Control of Reactions as a Prestressed Technique," by A. J. Harris. Midland Counties Branch. Birmingham and Midland Institute, Paradise-street, Birmingham. Tues., Feb. 1, 6 p.m.
LIVERPOOL
"A Prestressed-Concrete Bridge at Nottingham and Other Recent Works," by Dr. D. D. Matthews. North-Western Branch. 9 The Temple, 24 Dale-street, Liverpool. Tues., Feb. 1, 6.30 p.m.
MANCHESTER
"A Prestressed-Concrete Bridge at Nottingham and Other Recent Works," by Dr. D. D. Matthews. North-Western Branch. College of Technology, Manchester. Wed., Feb. 2, 6.45 p.m.

Royal Society

LONDON
"The Thermal Conductivity of Metals at Low Temperatures," by H. M. Rosenberg; and "Absorption Co-efficients in the Vacuum Ultra-Violet. Part III—Methane," by R. W. Ditchburn. Thurs., Feb. 3, 4.30 p.m.

Royal Society of Arts

LONDON
"Reconstruction of the Dutch Railways," by Ir. F. Q. den Hollander. Wed., Feb. 2, 2.30 p.m.

Sheffield Metallurgical Association

SHEFFIELD
"Recent Advances in the Radiography of Steel," by H. S. Peiser. B.I.S.R.A. Laboratories, Hoyle-street, Sheffield. Tues., Feb. 1, 7 p.m.

Women's Engineering Society

LONDON
"The Work of the British Standards Institution," by L. G. Watkins. London Branch. Wed., Feb. 2, 7 p.m.

The address and telephone number of the headquarters of each institution are given below. Meetings in the headquarters town are held there unless otherwise stated. Particulars for this column should reach the Editor not later than Monday morning in the week preceding the date of the meeting.

Association of Supervising Electrical Engineers, 23 Bloomsbury-square, London, W.C.1. (LANgham 5927.)
British Institution of Radio Engineers, 9 Bedford-square, London, W.C.1. (MUSeum 1901.)
Chemical Society, Burlington House, Piccadilly, London, W.1. (REGent 0675.)
Engineers' Guild, 78 Buckingham-gate, London, S.W.1. (ABBey 7315.)
Illuminating Engineering Society, 32 Victoria-street, London, S.W.1. (ABBey 5215.)
Incorporated Plant Engineers, 48 Drury-lane, Solihull, Birmingham. (Solihull 3021.)
Institute of Fuel, 18 Devonshire-street, Portland-place, London, W.1. (LANgham 7124.)
Institute of Marine Engineers, 85 The Minories, London, E.C.3. (ROYal 8493.)
Institute of Metals, 4 Grosvenor-gardens, London, S.W.1. (SLOane 6233.)
Institute of Road Transport Engineers, 69 Victoria-street, London, S.W.1. (ABBey 6248.)
Institute of Welding, 2 Buckingham Palace-gardens, London, S.W.1. (SLOane 9851.)
Institution of Civil Engineers, Great George-street, London, S.W.1. (WHItehall 4577.)
Institution of Electrical Engineers, Savoy-place, Victoria-embankment, London, W.C.2. (TEMple Bar 7676.)
Institution of Heating and Ventilating Engineers, 49 Cadogan-square, London, S.W.1. (SLOane 3158.)
Institution of Mechanical Engineers, 1 Birdcage-walk, St. James's Park, London, S.W.1. (WHItehall 7476.)
Institution of Production Engineers, 10 Chesterfield-street, London, W.1. (GROsvenor 5254.)
Institution of Structural Engineers, 11 Upper Belgrave-street, London, S.W.1. (SLOane 7128.)
Junior Institution of Engineers, Pepys House, 14 Rochester-row, London, S.W.1. (VICtoria 0786.)
Manchester Association of Engineers, 20 Booth-street, Manchester 2. (Central 2796.)
Reinforced Concrete Association, 94-98 Petty France, London, S.W.1. (ABBey 4504.)
Royal Society, Burlington House, Piccadilly, London, W.1. (REGent 3335.)
Royal Society of Arts, John Adam-street, Adelphi, London, W.C.2. (TRAfalgar 2366.)
Sheffield Metallurgical Association, 15 Crescent-road, Sheffield 7. (Sheffield 53674.)
Women's Engineering Society, 35 Grosvenor-place, London, S.W.1. (SLOane 0401.)